"EVALUATION OF MAXIMUM BITE FORCE IN PATIENTS REHABILITATED WITH COMPLETE DENTURE PROSTHESIS - AN IN VIVO STUDY"

A Dissertation submitted to

THE TAMILNADU DR. MGR MEDICAL UNIVERSITY

In partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

(BRANCH – I)

(PROSTHODONTICS AND CROWN & BRIDGE)

2014 – 2017

CERTIFICATE

This is to certify that **Dr. S.SRIVIDHYA,** Post Graduate student (2014 - 2017) in the Department of Prosthodontics and Crown and Bridge, has done this dissertation titled "**EVALUATION OF MAXIMUM BITE FORCE IN PATIENTS REHABILITATED WITH COMPLETE DENTURE PROSTHESIS - AN IN VIVO STUDY"** under my direct guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr. M.G.R. Medical University, Guindy, Chennai – 32** for **M.D.S.** in **Prosthodontics and Crown & Bridge (Branch I)** Degree Examination.

Guided by

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DECLARATION

I, Dr.S.SRIVIDHYA do hereby declare that the dissertation titled **"EVALUATION OF MAXIMUM BITE FORCE IN PATIENTS REHABILITATED WITH COMPLETE DENTURE PROSTHESIS - AN IN VIVO STUDY"** was done in the Department Of Prosthodontics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfilment of the requirements for the degree of **Master of Dental Surgery** in the speciality of **Prosthodontics and Crown & Bridge (Branch I)** during the course period **2014-2017** under the conceptualization and guidance of my dissertation guide, **Prof. Dr. C. SABARIGIRINATHAN.M.D.S.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG student **Signature of the HOD**

Signature of the Head of the Institution

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This agreement herein after the "Agreement" is entered into on this day, **December 23, 2016** between the **Tamil Nadu Government Dental College and Hospital** represented by its Principal having address at Tamil Nadu Government Dental College and Hospital, Chennai-3, (hereafter referred to as, 'the College')

And

Prof. Dr. C. SABARIGIRINATHAN.M.D.S., aged 50 years working as Professor and Head of Department of Prosthodontics and Crown and Bridge at Tamil Nadu Government Dental College and Hospital, Chennai-3 having residence address at E/32, Anna Nagar (East), Chennai- 102 (herein after referred to as the 'Researcher and Principal investigator')

And

Dr. S. SRIVIDHYA aged 28 years currently studying as Post Graduate student in the Department of Prosthodontics and Crown & Bridge, Tamil Nadu Government Dental College and Hospital, Chennai-3 (herein after referred to as the 'PG/Research student and Co- investigator').

Whereas the 'PG/Research student as part of her curriculum undertakes to research on the study titled **"EVALUATION OF MAXIMUM BITE FORCE IN PATIENTS REHABILITATED WITH COMPLETE DENTURE PROSTHESIS - AN IN VIVO STUDY"** for which purpose the Researcher and Principal investigator shall act as Principal investigator and the College shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator

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In witness whereof the parties herein above mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its Principal Student Guide

Witnesses PG Student

1.

2.

ACKNOWLEDGEMENT

I am extremely thankful to my chief **Dr. C. SABARIGIRINATHAN, M.D.S.,** Professor and Head of the Department and my Guide, Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital, Chennai. I consider it my utmost privilege and honor to express my most sincere and heartfelt gratitude to my esteemed chief and guide for his wholehearted support, constant guidance, help, encouragement, valuable suggestions and support he has rendered at various stages of the dissertation. I also thank him for the valuable guidance; he has given throughout my post graduation. Without his immense help this dissertation would not have come out in a befitting manner.

My sincere thanks to **Prof. Dr. B. SARAVANAN, M.D.S., PhD,** Principal, Tamil Nadu Government Dental College and Hospital for his kind help, valuable suggestions in this study and permitting me to use all the facilities in the institution. I also thank him for the valuable guidance he has given throughout the period of my post graduate course.

My sincere thanks to **Dr. A. MEENAKSHI, M.D.S.,** Professor, Department of Prosthodontics, Tamilnadu Government Dental College and Hospital for her valuable guidance throughout my study.

My sincere thanks to **Dr. K. VINAYAGAVEL, M.D.S.,** Professor, Department of Prosthodontics, Tamilnadu Government Dental College and Hospital for his valuable guidance throughout my study.

My sincere thanks to **Dr.P.RUPKUMAR M.D.S.,** Associate Professor, for helping and guiding me at all stages of this study.

I am thankful to **Dr.G.Sriramaprabu, M.D.S., Dr.M.Rajakumar, M.D.S.,** Associate Professors, for guiding and helping me at different stages of this study.

I am thankful to Senior Assistant Professor **Dr.T.Jeyanthikumari,M.D.S.,** Assistant Professors, **Dr.S.Vinayagam,M.D.S., Dr.J.Gandhimathi,M.D.S., Dr.V.Parimala,M.D.S., Dr.M.Kanmani,M.D.S., Dr.V.Harishnath,M.D.S., Dr.Preethi Chandran,M.D.S.,** and **Dr.SivaSakthiKumar,M.D.S.,** for helping me at different stages of this study.

I thank **Dr.Mohammed Junaith.M.D.S.**, for helping me to carry out the statistical analysis of the various test results.

A special thanks to my husband **Dr.S.Sathish M.D.S., my in-laws , my parents and my brother** for their constant support and motivation.

I owe my sincere thanks to **all my Colleagues, Senior and Junior postgraduates** in the department for their constant encouragement and timely help.

Above all I thank the **LORD GOD ALMIGHTY** for giving me the strength and courage to complete this monumental task.

LIST OF CONTENTS

LIST OF ABBREVIATIONS

SL.NO	ABBREVIATIONS
1	MBF- Maximum Bite Force
2	EMG- Electromography
3	lbs-Pounds
4	BMI-Body Mass Index
5	ANOVA-Analysis Of Variance

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ABSTRACT

Introduction: Bite force is an important variable used to assess the masticatory ability and performance of an individual. Among various factors that affect bite force, gender, facial form and arch form have been assessed in this study.

Keywords: Arch form, Bite Force, Completely edentulous, Facial form.

Aim: This clinical study aims at evaluating the maximum bite force of completely edentulous patients rehabilitated with complete dentures.

Materials and methods: 288 samples were divided into two groups (completely edentulous patients and dentulous subjects-144 each); each group into two subgroups (male and female-72 each) and each subgroup into subdivisions based on their facial form (Square, Square tapered, Tapered and Ovoid- 18 each) and arch forms (Square, Tapered and Ovoid- 6 each). The bite force was measured using Bite Force Sensor for both the groups and the mean values were statistically analyzed.

Results: ANOVA and Tukey's post-hoc Test revealed that the Square facial form showed the greatest bite force among other facial forms in all the subgroups and Square arch form showed the greatest bite force among other arch forms in most of the subgroups. Independent sample t-Test revealed a significant difference in most of the bite force values between males and females in both the groups and between all the edentulous and dentulous subjects.

Conclusion: Gender, facial form and arch form were found to be related to the bite force in both completely edentulous and dentulous subjects. Assessing these parameters in a patient could gain us an insight into their bite force and help us in better treatment planning, material selection, prosthesis design and evaluation and as reference value for future studies.

INTRODUCTION

INTRODUCTION:

Mastication is an important process for the stomatognathic system as it comprises the first step in food digestion. It is a cumulative phenomenon that comminutes food by increasing its surface area and exposing it to digestive juices[1]. Inefficient mastication leads to a change in the choice of an individual's diet that negatively influences his health and consequently leads to malnutrition[2]. Hence, a thorough knowledge of the masticatory system determines the success of any prosthodontic treatment.

It has become increasingly important to preserve the masticatory functions in elderly people for a better quality of life. It's traumatic for the patient, both physically and psychologically to experience the transition from having natural teeth to becoming edentulous and wear complete dentures. Functional performance of the complete dentures in contributing to the oral health and the quality of edentate people's life is thus a major concern in the geriatric dentistry[3].

Various factors such as the bite force, malocclusion, areas of occlusal contacts, loss of teeth, restorations, facial forms and other motor activities contribute to this masticatory performance. Among these, biting force is one of the key factors [4,5]. The number of bites taken to process and swallow food or the ability to break the food is a measure of the mastication process[2].

"Bite force is defined as the force of mandibular muscles that determines the amount of energy available to cut or grind food"[2]. Bite force is one of the indicators of the functional status of the masticatory system which results from jaw elevator muscle action and the craniomandibular biomechanics[6]. It has been used in understanding the mechanics of mastication, for evaluating the therapeutic effects of

prosthetic devices and in providing reference values for future studies[7]. It has also been considered quite important in diagnosing stomatognathic disturbances[8].

Complete denture wearers have shown to have a lower chewing efficiency when compared with dentate controls. This functional impairment applies to the maximum bite force (MBF) as well, which has been described to be almost five to six times lesser than in dentate subjects. Strength of the muscle and its cross-sectional area are affected by ageing and by the loss of teeth. Sensitivity and ageing properties of the load bearing mucosa over the alveolar ridge also limit an individual's MBF[3].

Intraoral force measurement has a long history and dates back to the 17th century. Borelli in 1681 designed a gnathodynamometer and did the first experimental study on the intra-oral forces. Black in 1893 designed a new type of gnathodynamometer, to measure intraoral forces due to vertical jaw movements[9]. From simple springs to complex electronic devices, a wide range of methods and devices have been utilized for the determination of bite forces. More precise and accurate measurements can now be made with the advancements in various electronic equipments.

The bite force can be measured directly using a transducer or by indirect evaluation by employing other physiologic variables (eg. EMG activity of the muscles) those are functionally associated to the force production[10].

Of various devices, strain gauge is a simple yet effective device. Strain-gauge metal force tranducers have been used in bite force studies by Manly and Vinton [11] and many others. Linderholm and Wennström[12] described one of the earliest designs of these transducers. Their transducer consisted of two steel bars formed into bite

plates at one end, and joined at the other end. Strain-gauges were connected in a Wheatstone Bridge circuit.

Several factors influence the direct measurements of the bite force. Investigators have found a great variation in bite force values, due to the difference in the anatomical and physiologic characteristics of each individual such as age, gender and craniofacial morphology.The mechanical properties of the bite force recording system also affect the accuracy and precision of the bite force levels.

Relationship of facial form to maximum bite force has been evaluated in dentulous and edentulous subjects [10.]

Symmetry, convexity, roundness and elongation of the dental arches together make up the arch form which contributes considerably to the diagnosis and treatment planning, space availability, prosthesis stability and esthetics due to the difference in its size and shape in each individual[13]. There is only one study[14] relating the arch form to the bite force in dentulous subjects.

Facial form has been found to be related to the arch form of the individual[15] and it has been stated that the arch form could be determined by the facial form[16,17].

If a valid relationship could be established between the patient's facial form, arch form and his bite force it could help in prognosis of the treatment and better education of the patient.

As there is no study relating the arch form to bite force in edentulous subjects, this study was formulated to determine the maximum bite force of edentulous subjects taking their facial form and arch form as the related factors using a strain gauge based force sensor device.

AIM
&
OBJECTIVES

AIM:

The aim of this study was to determine the maximum bite force in patients rehabilitated with complete denture prosthesis with a strain gauge based Bite Force Sensor.

OBJECTIVES:

- To evaluate the influence of factors such as gender, facial form (Square, Square-tapering, Tapering and Ovoid) and arch form (Square, Tapering, Ovoid) on maximum bite force in patients rehabilitated with complete dentures.
- To evaluate the influence of factors such as gender, facial form (Square, Square-tapering, Tapering and Ovoid) and arch form (Square, Tapering, Ovoid) on maximum bite force in dentulous subjects taken as control group.
- To compare the maximum bite force of completely edentulous subjects and dentulous subjects.

REVIEW OF LITERATURE

REVIEW OF LITERATURE:

Dr. G. E. Black (1895)[18], the President of Chicago Dental University devised the gnathodynamometer to measure the average strength of the jaws. When tested in thousand persons (men and women of all classes), an average of 171 pounds for the molar teeth was determined and a much lesser value for bicuspids and incisors.

Sargentini et al (1949)[19] showed that generally the magnitude of the maximum bite force are greater in men than in women and has been shown to decrease with age.

Bojanov (1969)[20] concluded that the higher bite force value in the molar region in the natural dentition is because of the greater periodontal area of the teeth distal in the arch.

Linderholm and Wennström (1970)[13] designed one of the earliest transducers. Their device consisted of two steel bars made into bite plates at one end, and were joined at the other end. Steel bars were applied with Strain-gauges and was further connected in Wheatstone bridge circuit. When the transducer was connected to a potentiometer writer, it was possible to record the load on the bite plates. The theory behind the operation is that any bending (loading) changes the resistance and results in a voltage change (electric potential). The voltage change can be calibrated with a known weight in order to indicate the applied load.

Wennstrom (1972)[21] reported that the maximum bite forces voluntarily generated by denture-wearers were only one fifth of those subjects with healthy natural dentition. Moreover, the "preference level" of bite force for denture wearers was about one eighth that of dentate subjects

Helkimo et al (1976)[22] analyzed the relationship between the type of dentition and bite force in 125 samples aged 15-65 years. The maximal forces ranged

between 10 and 73 kg. The authors highlighted that the decline in bite force values was in line with increasing age (especially in females) and also that a variation could be linked with dental status differences amongst participants. It was concluded that bite force magnitude may be five times greater in young individuals with natural dentition when compared to denture wearers.

Ralph W J (1979)[23] suggested that the bite force measurement device can be of adjunct value in assessing the performance of dentures.

Tarbet et a1 (1981)[24] concluded that denture wearers with good maxillary support , retention and stability were capable of biting with twice more than the force of denture wearers with unsatisfactory tissue support.

Ricketts (1982)[25] and **Graber (1966)**[26] showed that facial type and dental arch could be correlated. Dolichofacial patients were seen to have long, narrow faces, whereas brachyfacial patients were found to have short faces and broad arches.

Heath M.R. (1982)[27] reported that complete denture wearers have a masticatory efficiency of 16% to 50% as that of dentate subjects.

Proffit et al (1983)[28] quoted that a link exists between vertical facial morphology and bite force magnitude, in addition to weaker mandibular elevator muscles in studies with adults.

McWhirter (1985)[29] measured the greatest bite strength of 443 kg (975 lbs) in a 37-year-old man. It was found that the man had extraordinarily large, hypertrophied masseter and temporal muscles. The second greatest bite strength of 234 Kg (514lbs) was registered in a 43-year-old man. He was found to have hypertrophied masseter muscles along with tooth abrasion and heavy bone support from lingual tori. Biting strength of 975 lbs excels the world records for older achievements

like (1) bench press- 1300 Kg (660 lbs), (2) dead lift- 402 Kg (884 lbs) and (3) squat lift-545 Kg (1200 lbs).

Williams et al (1985)[30] studied the difference in bite force between complete dentures wearers and dentate individuals. The discrimination in bite force was analyzed at three standards - 500, 1000, and 3000 gm. Results revealed that the difference in bite force was not significant between the two groups. However, at 500 gm, the dentate group showed significantly better performance than the complete denture wearers.

Williams et al (1988)[31] studied if different extents of mouth opening had an effect on normal subjects' ability in discriminating differences in the inter incisor bite force. It was concluded that 50 to 90% of maximum opening does not alter the sensorimotor function for discrimination of bite-force by normal young adults.

Coffery et al (1989)[32] analysed the differences in discrimination ability in self-generated bite force using mandibular and maxillary first molars, premolars, canines and central incisors. Discrimination performance was seen to be better when the central incisors were used when compared to the first molars, which might be explained by the presence of different receptors within the periodontal ligament.

Bakke et al (1990)[33] investigated samples of 8-68 year old and said that larger bite force in males may be due to greater muscular potential.

Cecile G. Michael et al (1990)[34] found that the masticatory forces and bite strength in denture wearers fell below the range of natural dentition. The occlusal form of the posterior teeth in dentures did not increase the masticatory force significantly.

Kikuchi M. et al (1992)[35] said that the total maximum bite force generated with unilateral support was larger than with bilateral support and also there was an antero-posterior gradient of force with higher force being recorded at the posterior second molar region followed by the canine region based on the lever theory.

Kiliaridis et al (1993)[36] assessed the link between bite force and facial morphology in the 136 individuals aged 7- 24. Subject's facial morphology was determined by assessing different parameters from standardized photographs. Maximum bite force with incisors and upper /lower facial height ratio showed only slight positive links.

Osborne (1993)[37] recorded about190 N and 50 N as the maximum bite force values in the frontal area in men and women respectively.

Okeson (1993)[38] assumed that "ideal" occlusion of the teeth specifies even, simultaneous and bilateral tooth contacts in the intercuspal position that provide a balanced distribution of occlusal force. Maximum voluntary bite force is an important variable for assessing the functional state of the masticatory system in relation with occulsal factors, dentition, dental prostheses, implant treatment, orthognathic surgery, oral surgery, temporomandibular disorders and neuromuscular disease.

Braun et al (1995)[39] said that magnitude of maximum bite force varies with changes in the cranio facial growth, which complements the growth of masticatory muscles and also the normal growth process

Lyons et al (1996)[40] quoted that even though strain-gauge transducers have been proven to be an accurate method for maximum bite force measurement, recording a true maximum bite force would still be difficult. This is mainly because biting on the hard metal surfaces of the transducers causes discomfort and fear of

breaking of edges and of teeth and restorations. He also concluded that although the protective covers have decreased the discomfort to some extent the fear and the discomfort associated with biting on the hard surfaces has not been overcome totally.

Tortopidis et al (1998)[41] said that the position of the recording device within the oral cavity differs. Generally, stronger bite forces are found in the posterior region of the dental arch as acknowledged by two different theories. First is the mechanical lever system of the jaw. Secondly, premolars and molars (posterior teeth) withstand greater forces than the anteriors.

Patterson (1998)[42] said that, bite force has been used to assess prosthetic devices and to provide reference values for researches in the field of biomechanics of prosthetic device.

Ow et al (1998)[43] found that bite force is one of the important elements involved in chewing action and is regulated by the "dental, muscular, nervous and skeletal systems and exerted by the jaw elevator muscle".

Tsuga K. et al (1998)[44] assessed the masticatory ability, dental state and bites force in 160 eighty year old persons and found that the edentulous persons (about one-fifth of all) reported more problems related to mastication than the other definition groups. The maximal bite force varied much based on the number of remaining teeth and dental state. The self-assessed masticatory ability was weakly correlated with dental state and bite force and many subjects showed a good adaptation to an impaired dental status and small maximal bite force.

Tortopidis et al (1999)[45] attempted to reduce the discomfort occurring on biting on the hard surfaces of strain gauge transducers. Various materials such as gauze,

gutta percha, polyvinyl chloride and acrylic resin have been used to cover the transducers.

Kanashiro et al (2000)[46] contrasted arch widths with facial types and showed that the width of posterior segment increased from dolichofacial to brachyfacial type and the mathematical arch depth increased from mesofacial to brachyfacial type.

Sonneson et al (2001)[47] analysed maximum bite forces to examine the connection between craniofacial morphology, temporomandibular joint dysfunction and head position. Study sample included children who were about to receive orthodontic treatment.

Hatch et al (2001)[48] studied the biting force in patients of age range between 45 to 60 years to avoid variation in masticatory performance and reported that the age factor might directly affect the biting force.

Ortug (2002)[1] quoted that Borelli was one of the first to assess intraoral forces, by designing the gnathodynamometer. Weights attached to a cord were passed over the molar teeth when mandible was open, and with the closing of the jaw it was raised up to 440 lbs (200 kg). In 1893, Black redesigned and modified the tool.

Fernandes et al (2003)[5] said that most of the modern devices utilize electrical resistance strain gauges and that the majority of the recording instruments have the ability to record forces between 0 N and 800 N at 80% precision and accuracy.

Sonnesen and Bakke (2005)[49] and **Usui et al (2007)**[50] stated that bite force increases with age until 20 years of age at which point bite force will be stabilized. However, at 40 years of age, bite force starts decreasing.

Sonnesen and Bakke (2005)[49] highlight the presence of a relationship between bite force and cranio-facial morphology. Vertical jaw relationship was the most

fundamental considerations with regards to craniofacial morphology's impact on boys' bite force. It was stated that males with a shorter and lower facial height were found to have a greater degree of bite force.

Toru et al (2006)[51]analysed and said that the mandibular dental arch forms were not found to be correlated with all coefficients and facial types. Due to the anteroposterior rotation of mandible in malocclusion, the prevalence of mandibular arch form might be extremely low.

Usui et al (2007)[50] quoted that repeated recording can result in reduced bite force due to muscle fatigue. While investigating bite force, the number of recordings required must be determined by considering the reliability and also by avoiding fatigue that will cause reduced bite force magnitude.

Olthoft et al (2007)[52] said that increasing in the vertical dimension results in variations in the orofacial morphology. Subsequently, this affects the masticatory system and bite force values.

Koc et al (2010)[2] stated that in clinical practice, bite force is measured to assess dental prosthesis and accordingly to determine the success of rehabilitation in adults. Such calculations were also pointed towards obtaining bite force reference ranges to guide prosthetic device and implant designing.

The cranio-facial morphology includes the anterior and posterior facial height ratio, mandible inclination, and gonial angle. The maximum bite force suggested the geometry of the mandible's lever system. He said that bite force evaluations were aimed at determining muscular activity and movements of jaw during the chewing function. Measurements are also indispensible in terms of evaluation of masticatory efficiency.

He also reported that the degree of jaw separation had an influence on the bite force and 14-20 mm was found to be the range of mean jaw separation for recording bite forces.

Duygu et al (2011)[53] concluded that in individuals with normal occlusion, the mean maximum bite force was higher in men than in women; transverse facial dimensions had an influence on bite force only in men, suggesting that men with long faces tended to have a lower bite force than those with normal face. It was also found that the type of functional occlusion and interferences on balancing side did not have any influence on maximum bite force.

Sarah et al(2014)[7] assessed the maximum bite force in individuals with Angle's malocclusions and in those with normal occlusion and found that the type of occlusion had an influence on bite force, with greater force being seen in individuals with normal occlusion, followed by Angle's malocclusion classes I, II and III respectively. There was an increase in mean bite force measured between the first and third attempt. There was no significant difference in force measurements between the right and left sides.

Nickolay (2014)[54] analysed and found that the maximum bite force in female subjects is lesser than that in male subjects. The force in the left and right molar regions was almost equal, whereas they are about 3 times the values in the frontal region.

Veena Jain et al (2014)[14] analysed the mean maximum bite force in 358 Indian subjects considering the influence of various factors namely gender, BMI, facial form, facial profile, arch form and palatal contour. They recorded the bite force using a customized instrument with a quartz force sensor. The mean maximum bite force was found to be 372.39 ± 175.93 N.

Bite force was significantly higher in: males than in females; in subjects with concave profile, as compared to straight and convex profile and in square facial form when compared to ovoid, square tapered and tapered facial form. Relationship was not found between BMI and bite force.

Gaurav T et al (2014)[10] studied the mean maximum bite force in 80 dentulous and 80 edentulous individuals with different facial forms and concluded that the dentulous as well as edentulous individuals with square face had higher maximum bite force. He quoted that the vertical ramus and acute gonial angle could have provided greater mechanical advantage to the elevator muscles.

Sanjna et al (2015)[15] analysed the association between arch form and facial form in dentulous patients. In the upper arch of leptoprosophic faces, square arch (63.63%) was predominant whereas in mesoprosophic faces ovoid arches were predominant (54.6%).

MATERIALS
&
METHODS

MATERIALS AND METHODOLOGY:

The present study was conducted to evaluate the maximum bite force in patients rehabilitated with complete dentures and compare it with that of the dentulous control subjects.

The study was conducted in the Department of Prosthodontics and Crown and Bridge, Tamilnadu Government Dental College and Hospital, Chennai.

ETHICAL COMMITTEE APPROVAL:

This study was conducted with the approval of the Institutional Ethical Committee.

The following materials and equipments were used to conduct the study**:**

ARMAMENTARIUM FOR CLINICAL EXAMINATION: (Fig.1)

1. Kidney tray
2. Mouth mirror
3. Williams Periodontal probe
4. Check retractor
5. Disposable glove and mask

ARMAMENTARIUM FOR STUDY MODELS AND FABRICATION OF COMPLETE DENTURE: (Fig.2)

1. Maxillary and mandibular stock trays- edentulous and dentulous
2. Alginate –Algitex (DPI)
3. Medium fusing impression compound (DPI)
4. Type III dental stone
5. Type II dental plaster
6. Autopolmerizing acrylic resin (DPI)
7. Putty addition silicon impression material (Aquasil soft putty, DENTSPLY)

8. Light body addition silicon impression material (Aquasil LV, DENTSPLY)
9. Tray adhesive (Virtual, ivoclar vivadent)
10. Modelling wax (HIFLEX)
11. Hard wax (Cavex)
12. Dentatus face bow and articulator
13. Acryrock ruthenium teeth set
14. Heat cure acrylic resin (DPI)

ARMAMENTARIUM FOR EVALUATING THE BITE FORCE

1. **Bite Force Sensor HE6210** (HariOm Electronics, Gujarat)
2. Digital display box (HariOm Electronics, Gujarat).
3. 2mm thick thermoplastic sheet.
4. Disposable sleeves
5. Surgical gloves
6. Surgical spirit

METHODOLOGY:

STUDY POPULATION:

Completely edentulous patients (age group: 50 to 70 years) who were scheduled for complete denture fabrication were selected for the study. Dentulous control group comprised of subjects of age 20-30 years.

SAMPLE SIZE AND DESIGN:

A total of 288 samples were included in the study. The samples were divided into two groups- Completely edentulous (144) and Dentulous subjects (control group-144). Each group was divided into two subgroups- Male (72) and Female (72).

Each subgroup was further classified into subdivisions based on their facial form and arch form into:

i. Square facial form (n=18):

Square arch form (n=6), Tapered arch form (n=6), Ovoid arch form (n=6)

ii. Square tapered facial form (n=18):

Square arch form (n=6), Tapered arch form (n=6), Ovoid arch form (n=6)

iii. Tapered facial form (n=18):

Square arch form (n=6), Tapered arch form (n=6), Ovoid arch form (n=6)

iv. Ovoid facial form (n=18):

Square arch form (n=6), Tapered (n=6), Ovoid arch form (n=6)

EXAMINATION:

All participants were examined clinically and radiograpically to ensure absence of pathology of residual alveolar ridge, mucosa or bone.

CRITERIA FOR SELECTION:

INCLUSION CRITERIA:

EDENTULOUS SUBJECTS:

1. Patients willing for voluntary participation and have signed informed consent.
2. Completely edentulous patients, with well contoured ridge covered by healthy mucosa.
3. Age group 50-70 years.
4. Patients without prior complete denture experience.
5. Systemically healthy individuals.
6. Absence of any pathology around the area of interest.

DENTULOUS SUBJECTS:

1. Age group between 20- 30 years

2. Presence of complete permanent dentition with Angle's class I molar relationship (excluding third molars).

EXCLUSION CRITERIA:

EDENTULOUS SUBJECTS:

1. Patients with facial asymmetry.
2. Acute infection.
3. Medically compromised individuals.
4. Patients on radiotherapy.
5. Patients who have had trauma in craniofacial structures.
6. Patients who have undergone any surgery in craniofacial structures.
7. Patients with temporomandibular disorders.
8. Patient with poor neuromuscular control.
9. Debilitated individuals.
10. Flat /spiny/flabby ridge.
11. Mentally challenged persons.
12. Any form of tobacco users.

DENTULOUS SUBJECTS:

Criteria in addition to those of the edentulous patients:

1. History of parafunctional habits.
2. Occlusal rehabilitation by splint or muscle relaxant.
3. Orthodontic treatment or dental prosthesis.
4. Any type of restoration.
5. Periodontal diseases.

FLOW CHART- STUDY DESIGN:

PHASE I – CLINICAL EXAMINATION AND IMPRESSION PROCEDURES FOR STUDY MODELS

↓

PHASE II – ESTABLISHMENT OF FACIAL FORM AND ARCH FORM FOR COMPLETELY EDENTULOUS AND DENTULOUS SUBJECTS.

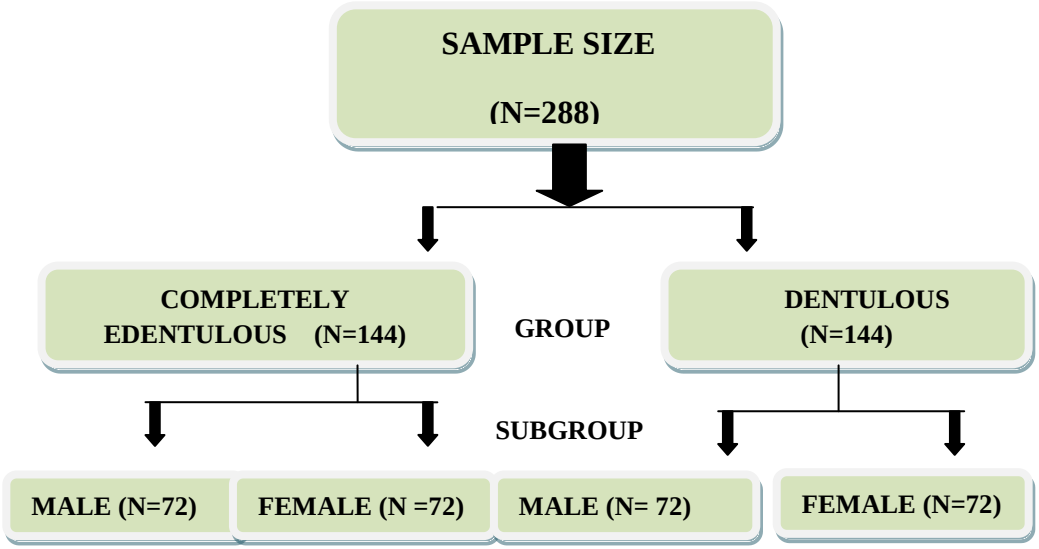
↓

PHASE III – COMPLETE DENTURE FABRICATION FOR COMPLETELY EDENTULOUS SUBJECTS

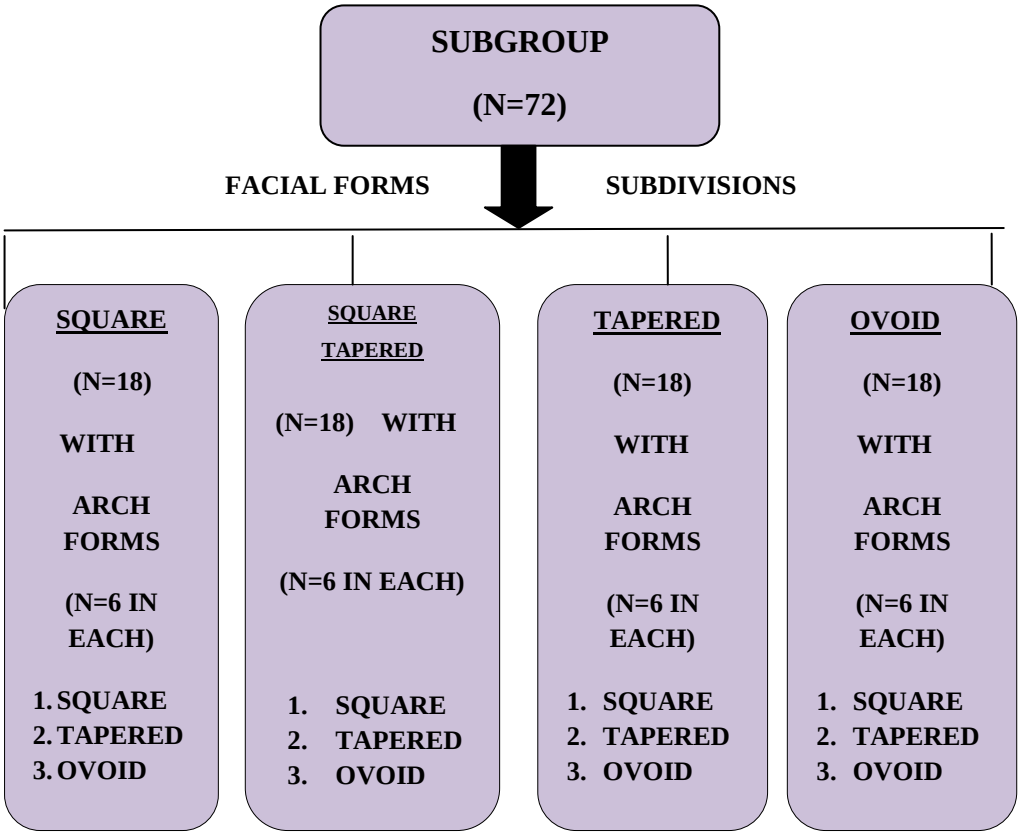
↓

PHASE IV– BITE FORCE EVALUATION IN COMPLETELY EDENTULOUS PATIENTS REHABILITATED WITH COMPLETE DENTURES (ONE MONTH POST-INSERTION) AND CONTROL GROUP

STUDY SAMPLE:



Each subgroup is further classified based on their facial form and arch form.



EXPERIMENTAL PROTOCOL:

PHASE I – Clinical examination and impression procedures for study model fabrication.

PHASE II – Establishment of facial form and arch form for completely edentulous and dentulous control subjects.

PHASE III – Complete denture fabrication for completely edentulous patients.
PHASE IV– Bite force evaluation in completely edentulous patients rehabilitated with compete dentures (one month post-insertion) and in the control group.

CLINICAL PROCEDURES:

PHASE I

1. Medical and dental history was obtained**.** Clinical examination was done.
2. For completely edentulous patients, primary impressions of maxillary and mandibular ridges were recorded with medium fusing impression compound and casts were poured with type II dental plaster.
3. For dentulous subjects, alginate impressions were made for the maxillary and mandibular arches and casts were poured with type III dental stone.

PHASE II-

ESTABLISHMENT OF FACIAL FORM:

Facial dimensions were determined by measurements made on standardized digital photographs. The camera (Cyber-shot DSC W110; Sony, Japan) was positioned at 1m distance from subjects and adjusted to the same level of the subject's eyes. Frontal photographs were taken with the Frankfort plane approximately parallel to the floor. The obtained digital images were 2048x1536 pixels in size and 5.1 megapixels in resolution. The images were analyzed using Adobe Photoshop CS3. Facial midline was drawn. Two vertical lines on the outer contour of face were

marked. Horizontal lines were placed in supraorbital ridge and at the base of nose perpendicular to facial midline dividing the face into three parts. Then the facial form was evaluated based on the relation between facial outline and vertical line in both the groups as follows:

Square - facial outline almost parallel to the vertical guide lines. (Fig.3, 7).

Square-tapered - facial outline tapering inward from middle third of face (Fig.4, 8).

Tapered - facial outline tapering inward from upper third of the face (Fig.5, 9).

Ovoid - a curved facial outline against the vertical guide lines (Fig.6, 10).

ESTABLISHMENT OF ARCH FORM:

Edentulous upper arch forms were classified as **Square, Tapered and Ovoid**. (Fig. 11, 13, 15).

For the dentulous subjects, the distance between the intercanine line to incisal surface of maxillary central incisor was measured on the maxillary study model and the arch form was divided into:

Square -The arch form with central incisors nearly in line with the canines (Fig.12).

Tapered -The arch form with central incisors at a greater distance forward from the canines (Fig.14).

Ovoid -The arch form with central incisors forward of canines in positions between that of square and tapered arch (Fig.16).

PHASE III

1. Custom trays were fabricated using auto-polymerizing resin on the primary edentulous casts and peripheral tracing was performed by putty material and wash impression was made with light body impression material and master casts were made with dental stone.

2. Occlusal wax rims for upper and lower arch were fabricated. Face bow

transfer was made to record the maxillomandibular relationship and casts were articulated.

3. Semi-anatomic teeth were set according to the principles of teeth arrangement.

4. The try in of the waxed denture was done and dentures were processed using heat cure acrylic material.

5. Dentures were inserted; occlusal discrepancies were checked and addressed followed by post-insertion instructions for denture use.

6. Follow up appointments were planned after 24 hr, 1 week and1 month.

PHASE IV

1. The Bite Force Sensor device (Fig.17) was calibrated by applying known weights of 1 kg, 2kg and 5 kg before recording any values.

2. A 2mm thick thermoplastic sheet was used (Fig.18) to protect the teeth from getting damaged while applying bite pressure and it was further covered by disposable sleeves to protect it from cross contamination.

3. The patient was seated in an upright position in dental chair, keeping the maxillary plane approximately parallel to the floor. The strain gauge was also maintained parallel to the maxillary denture and evaluated intraorally for proper position and comfort.

4. The device was placed unilaterally, positioned between the most distal maxillary and mandibular molars for dentulous subject and between the second premolars and first molar for completely edentulous subjects with complete dentures.

5. Bite force was recorded for 2-3 times till the subjects got familiar with the device. After each recording, one minute was allowed to pass before the next recording. Then the maximum bite force values were finally documented for right and

left side of each subject (Fig.19-22) and their mean value was taken for the statistical analysis.

STATISTICAL ANALYSIS:

The scores attributed to each group were recorded. The comparisons between averages were performed using SPSS -16 software. Quantitative data obtained in the present study was assessed for normality using Shapiro Wilk's test and was found to be parametric in nature. Inter-group analysis of bite force between different facial forms and arch forms was carried out using one-way ANOVA followed by Tukey's post-hoc test. Bite force comparisons between dentulous and edentulous arches and gender respectively was carried out using independent sample t-test. $P<0.05$ was considered significant in the present study.

Fig.1 ARMAMENTARIUM FOR CLINICAL EXAMINATION

Fig.2 ARMAMENTARIUM FOR STUDY MODELS AND COMPLETE DENTURE FABRICATION

Fig.3 SQUARE FACIAL FORM- EDENTULOUS PATIENT

Fig.4 SQUARE TAPERED FACIAL FORM- EDENTULOUS PATIENT

Fig.5 TAPERED FACIAL FORM- EDENTULOUS PATIENT

Fig.6 OVOID FACIAL FORM- EDENTULOUS PATIENT

Fig.7 SQUARE FACIAL FORM- DENTULOUS SUBECT

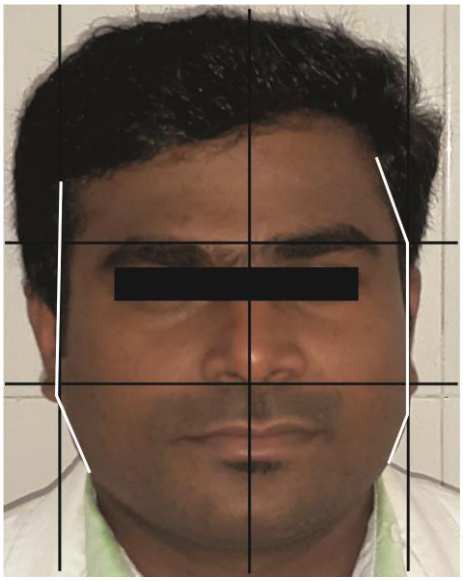


Fig.8 SQUARE TAPERED FACIAL FORM- DENTULOUS SUBECT

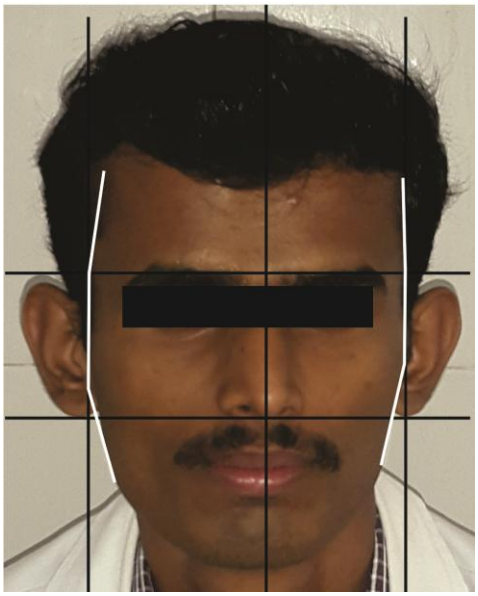


Fig. 9 TAPERED FACIAL FORM- DENTULOUS SUBECT

Fig. 10 OVOID FACIAL FORM- DENTULOUS SUBECT

SQUARE ARCH FORM

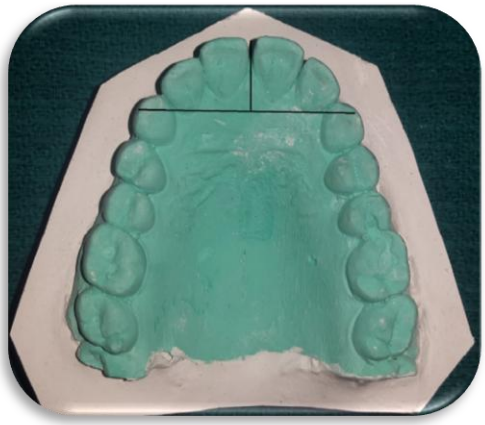
Fig.11 Edentulous Square Arch

Fig.12 Dentulous Square Arch

TAPERED ARCH FORM

Fig.13 Edentulous Tapered Arch

Fig.14 Dentulous Tapered Arch



OVOID ARCH FORM

Fig.15 Edentulous Ovoid Arch

Fig.16 Dentulous Ovoid Arch

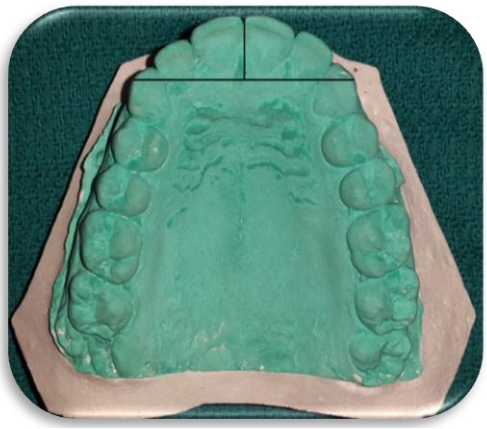


Fig.17 BITE FORCE SENSOR HE 6210 AND DIGITAL DISPLAY BOX

Fig.18 THERMOPLASTIC SHEET COVERING THE TRANSDUCER

Fig.19 BITE FORCE MEASUREMENT IN DENTULOUS SUBECT-LEFT SIDE

Fig.20 BITE FORCE MEASUREMENT IN DENTULOUS SUBECT-RIGHT SIDE

Fig.21 BITE FORCE MEASUREMENT IN EDENTULOUS SUBJECT- RIGHT SIDE

Fig.22 BITE FORCE MEASUREMENT IN EDENTULOUS SUBJECT- LEFT SIDE

RESULTS

TABLE 1:

COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT FACIAL FORMS IN THE SUBGROUPS BY DESCRIPTIVE STATISTICS:

Subgroup	Facial form	N	Mean	Std. Deviation
DENTULOUS MALE	Square	18	44.0342	5.65372
	Square Tapered	18	39.6206	7.21575
	Tapered	18	38.9712	7.87573
	Ovoid	18	35.4034	5.89018
	Total	72	39.5074	7.26776
DENTULOUS FEMALE	Square	18	34.9926	6.55704
	Square Tapered	18	33.7128	5.19172
	Tapered	18	31.6166	3.84769
	Ovoid	18	29.4000	4.49899
	Total	72	32.4305	5.43828
EDENTULOUS MALE	Square	18	5.9155	1.13397
	Square Tapered	18	5.0034	1.34147
	Tapered	18	4.9555	0.59668
	Ovoid	18	4.2586	0.85952
	Total	72	5.0333	1.16280
EDENTULOUS FEMALE	Square	18	3.8506	0.88315
	Square Tapered	18	3.7180	0.49612
	Tapered	18	3.3750	0.37480
	Ovoid	18	2.9108	0.82518
	Total	72	3.4636	0.75907

TABLE 2:

COMPARISON OF MEAN BITE FORCE IN DIFFERENT FACIAL FORMS BETWEEN AND WITHIN THE SUBGROUPS BY ONE WAY ANOVA TEST:

MeanBiteforce		Sum of Squares	df	Mean Square	F	**Sig.**
DentulousMale	Between Groups	677.440	3	225.813	4.997	**0.003**
	Within Groups	3072.799	68	45.188		
	Total	3750.240	71			
DentulousFemale	Between Groups	314.917	3	104.972	3.999	**0.011**
	Within Groups	1784.903	68	26.249		
	Total	2099.820	71			
EdentuousMale	Between Groups	24.936	3	8.312	7.954	**0.000**
	Within Groups	71.064	68	1.045		
	Total	96.000	71			
EdentulousFemale	Between Groups	9.502	3	3.167	6.858	**0.000**
	Within Groups	31.407	68	.462		
	Total	40.909	71			

TABLE 3:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT FACIAL FORMS IN DENTULOUS MALE USING TUKEY HSD-POST HOC TEST

Subgroup	Facial form (I)	Groups (J)	Mean Difference (I-J)	Sig.
DENTULOUS MALE	Square	Square Tapered	4.41358	0.210
		Tapered	5.06300	0.118
		Ovoid	8.63086*	**0.001**
	Square Tapered	Square	-4.41358	0.210
		Tapered	0.64942	0.991
		Ovoid	4.21728	0.245
	Tapered	Square	-5.06300	0.118
		Square Tapered	-0.64942	0.991
		Ovoid	3.56786	0.390
	Ovoid	Square	-8.63086*	**0.001**
		Square Tapered	-4.21728	0.245
		Tapered	-3.56786	0.390

*. The mean difference is significant at the 0.05 level.

TABLE 4:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT FACIAL FORMS IN DENTULOUS FEMALE USING TUKEY HSD-POST HOC TEST

Subgroup	Facial form (I)	Groups (J)	Mean Difference (I-J)	Sig.
DENTULOUS FEMALE	Square	Square Tapered	-0.72014	0.975
		Tapered	2.37600	0.509
		Ovoid	4.59264*	**0.044**
	Square Tapered	Square	0.72014	0.975
		Tapered	3.09614	0.276
		Ovoid	5.31278*	**0.014**
	Tapered	Square	-2.37600	0.509
		Square Tapered	-3.09614	0.276
		Ovoid	2.21664	0.567
	Ovoid	Square	-4.59264*	**0.044**
		Square Tapered	-5.31278*	**0.014**
		Tapered	-2.21664	0.567

*. The mean difference is significant at the 0.05 level.

TABLE 5:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT FACIAL FORMS IN EDENTULOUS MALE USING TUKEY HSD-POST HOC TEST

Subgroup	Facial form (I)	Groups (J)	Mean Difference (I-J)	Sig.
EDENTULOUS MALE	Square	Square Tapered	0.91211*	**0.045**
		Tapered	0.95997*	**0.031**
		Ovoid	1.65686*	**0.000**
	Square Tapered	Square	-0.91211*	**0.045**
		Tapered	0.04786	0.999
		Ovoid	0.74475	0.138
	Tapered	Square	-0.95997*	**0.031**
		Square Tapered	-0.04786	0.999
		Ovoid	0.69689	0.182
	Ovoid	Square	-1.65686*	**0.000**
		Square Tapered	-0.74475	0.138
		Tapered	-0.69689	0.182

*. The mean difference is significant at the 0.05 level.

TABLE 6:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT FACIAL FORMS IN EDENTULOUS FEMALE USING TUKEY HSD-POST HOC TEST

Subgroup	Facial form (I)	Groups (J)	Mean Difference (I-J)	Sig.
EDENTULOUS FEMALE	Square	Square Tapered	0.13256	0.936
		Tapered	0.47558	0.164
		Ovoid	0.93975*	**0.001**
	Square Tapered	Square	-0.13256	0.936
		Tapered	0.34303	0.435
		Ovoid	0.80719*	**0.004**
	Tapered	Square	-0.47558	0.164
		Square Tapered	-0.34303	0.435
		Ovoid	0.46417	0.181
	Ovoid	Square	-0.93975*	**0.001**
		Square Tapered	-0.80719*	**0.004**
		Tapered	-0.46417	0.181

*. The mean difference is significant at the 0.05 level.

TABLE 7:

COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN EDENTULOUS MALE BY DESCRIPTIVE STATISTICS

Facial Form	Arch form	N	Mean	Std. Deviation	Minimum	Maximum
Square	Square	6	6.9178	0.75797	5.57	7.69
	Tapered	6	6.1484	0.67230	5.37	7.39
	Ovoid	6	4.6802	0.49376	4.03	5.45
	Total	18	5.9155	1.13397	4.03	7.69
Square Tapered	Square	6	6.0512	0.91495	4.80	6.97
	Tapered	6	5.3335	0.78644	4.50	6.37
	Ovoid	6	3.6255	0.96766	2.88	5.55
	Total	18	5.0034	1.34147	2.88	6.97
Tapered	Square	6	5.3982	0.36782	4.79	5.84
	Tapered	6	4.9228	0.43440	4.43	5.41
	Ovoid	6	4.5457	0.66969	3.94	5.30
	Total	18	4.9555	0.59668	3.94	5.84
Ovoid	Square	6	4.5062	0.98372	3.37	5.48
	Tapered	6	4.5157	0.94937	3.39	5.54
	Ovoid	6	3.7541	0.42954	3.32	4.33
	Total	18	4.2586	0.85952	3.32	5.54

TABLE 8:

COMPARISON OF MEAN BITE FORCE BETWEEN AND WITHIN FACIAL FORMS IN EDENTULOUS MALE BY ONE WAY ANOVA TEST

Facial form-mean bite force		Sum of Squares	df	Mean Square	F	**Sig.**
Square	Between Groups	15.509	2	7.754	18.313	**0.000**
	Within Groups	6.352	15	.423		
	Total	21.860	17			
SquareTapered	Between Groups	18.632	2	9.316	11.684	**0.001**
	Within Groups	11.960	15	.797		
	Total	30.592	17			
Tapered	Between Groups	2.190	2	1.095	4.252	**0.034**
	Within Groups	3.862	15	.257		
	Total	6.052	17			
Ovoid	Between Groups	2.291	2	1.146	1.674	0.221
	Within Groups	10.268	15	.685		
	Total	12.559	17			

TABLE 9:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN EDENTULOUS MALE BY TUKEY HSD-POST HOC TEST

Facial form	(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
Square	Square	Tapered	0.76942	0.135
		Ovoid	2.23758	**0.000**
	Tapered	Square	-0.76942	0.135
		Ovoid	1.46817	**0.004**
	Ovoid	Square	-2.23758	**0.000**
		Tapered	-1.46817*	**0.004**
Square Tapered	Square	Tapered	0.71767	0.370
		Ovoid	2.42567*	**0.001**
	Tapered	Square	-0.71767	0.370
		Ovoid	1.70800	**0.012**
	Ovoid	Square	-2.42567	**0.001**
		Tapered	-1.70800*	**0.012**
Tapered	Square	Tapered	0.47542	0.267
		Ovoid	0.85250	**0.027**
	Tapered	Square	-0.47542	0.267
		Ovoid	0.37708	0.424
	Ovoid	Square	-0.85250*	**0.027**
		Tapered	-0.37708	0.424
Ovoid	Square	Tapered	-0.00950	1.000
		Ovoid	0.75208	0.287
	Tapered	Square	0.00950	1.000
		Ovoid	0.76158	0.278
	Ovoid	Square	-0.75208	0.287
		Tapered	-0.76158	0.278

*. The mean difference is significant at the 0.05 level.

TABLE 10:

COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN EDENTULOUS FEMALE BY DESCRIPTIVE STATISTICS:

Facial form	Arch form	N	Mean	Std. Deviation	Minimum	Maximum	**Sig.**
Square	Square	6	4.3925	0.55882	3.53	5.00	**0.000**
	Tapered	6	4.3113	0.16675	4.11	4.52	
	Ovoid	6	2.8478	0.70568	2.12	4.02	
	Total	18	3.8506	0.88315	2.12	5.00	
Square Tapered	Square	6	3.9071	0.37015	3.43	4.33	**0.014**
	Tapered	6	3.9763	0.26550	3.63	4.34	
	Ovoid	6	3.2706	0.51589	2.59	4.08	
	Total	18	3.7180	0.49612	2.59	4.34	
Tapered	Square	6	3.3917	0.25984	3.14	3.90	0.152
	Tapered	6	3.5765	0.49631	2.89	4.17	
	Ovoid	6	3.1568	0.23989	2.82	3.56	
	Total	18	3.3750	0.37480	2.82	4.17	
Ovoid	Square	6	3.0139	0.32496	2.45	3.29	0.744
	Tapered	6	2.6878	0.50512	1.96	3.29	
	Ovoid	6	3.0307	1.36555	1.78	5.02	
	Total	18	2.9108	0.82518	1.78	5.02	

TABLE 11:

COMPARISON OF MEAN BITE FORCE BETWEEN AND WITHIN FACIAL FORMS IN EDENTULOUS FEMALE BY ONE WAY ANOVA TEST

Facial form- mean bite force		Sum of Squares	df	Mean Square	F	**Sig.**
Square	Between Groups	9.069	2	4.534	16.232	**0.000**
	Within Groups	4.190	15	.279		
	Total	13.259	17			
SquareTapered	Between Groups	1.816	2	.908	5.751	**0.014**
	Within Groups	2.368	15	.158		
	Total	4.184	17			
Tapered	Between Groups	.531	2	.266	2.145	0.152
	Within Groups	1.857	15	.124		
	Total	2.388	17			
Ovoid	Between Groups	.448	2	.224	.302	0.744
	Within Groups	11.127	15	.742		
	Total	11.576	17			

TABLE 12:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN EDENTULOUS FEMALE BY TUKEY HSD-POST HOC TEST

Facial form	(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
Square	Square	Tapered	0.08117	0.962
		Ovoid	1.54467*	**0.000**
	Tapered	Square	-0.08117	0.962
		Ovoid	1.46350*	**0.001**
	Ovoid	Square	-1.54467*	**0.000**
		Tapered	-1.46350*	**0.001**
Square Tapered	Square	Tapered	-0.06925	0.951
		Ovoid	0.63650*	**0.036**
	Tapered	Square	0.06925	0.951
		Ovoid	.070575*	**0.020**
	Ovoid	Square	-0.63650*	**0.036**
		Tapered	-0.70575*	**0.020**
Tapered	Square	Tapered	-0.18483	0.643
		Ovoid	0.23492	0.496
	Tapered	Square	0.18483	0.643
		Ovoid	0.41975	0.131
	Ovoid	Square	-0.23492	0.496
		Tapered	-0.41975	0.131
Ovoid	Square	Tapered	0.32608	0.792
		Ovoid	-0.01675	0.999
	Tapered	Square	-0.32608	0.792
		Ovoid	-0.34283	0.773
	Ovoid	Square	0.01675	0.999
		Tapered	0.34283	0.773

*. The mean difference is significant at the 0.05 level.

TABLE 13:

COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN DENTULOUS MALE BY DESCRIPTIVE STATISTICS:

Facial form	Arch form	N	Mean	Std. Deviation	Minimum	Maximum
Square	Square	6	47.9300	6.68790	35.89	53.80
	Tapered	6	43.3971	4.94530	38.69	52.09
	Ovoid	6	40.7756	2.83783	36.27	44.88
	Total	18	44.0342	5.65372	35.89	53.80
Square Tapered	Square	6	43.1938	7.07779	35.73	53.86
	Tapered	6	37.8915	7.69631	28.00	50.89
	Ovoid	6	37.7767	6.68662	26.57	43.51
	Total	18	39.6206	7.21575	26.57	53.86
Tapered	Square	6	44.7172	5.32122	37.51	50.37
	Tapered	6	40.6299	6.00974	31.72	48.07
	Ovoid	6	31.5665	6.14347	27.12	43.74
	Total	18	38.9712	7.87573	27.12	50.37
Ovoid	Square	6	38.6840	4.99795	29.55	43.01
	Tapered	6	36.0243	5.52471	27.28	41.87
	Ovoid	6	31.5018	5.55099	24.09	37.29
	Total	18	35.4034	5.89018	24.09	43.01

TABLE 14:

COMPARISON OF MEAN BITE FORCE BETWEEN AND WITHIN FACIAL FORMS IN DENTULOUS MALE BY ONE WAY ANOVA TEST

Facial form-mean bite force		Sum of Squares	df	Mean Square	F	Sig.
Square	Between Groups	157.211	2	78.605	3.053	0.077
	Within Groups	386.187	15	25.746		
	Total	543.397	17			
SquareTapered	Between Groups	114.944	2	57.472	1.119	0.352
	Within Groups	770.196	15	51.346		
	Total	885.139	17			
Tapered	Between Groups	543.588	2	271.794	7.980	**0.004**
	Within Groups	510.873	15	34.058		
	Total	1054.461	17			
Ovoid	Between Groups	158.225	2	79.112	2.750	0.096
	Within Groups	431.577	15	28.772		
	Total	589.802	17			

TABLE 15:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN DENTULOUS MALE BY TUKEY HSD-POST HOC TEST

Facial form	(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
Square	Square	Tapered	4.53292	0.298
		Ovoid	7.15442	0.067
	Tapered	Square	-4.53292	0.298
		Ovoid	2.62150	0.652
	Ovoid	Square	-7.15442	0.067
		Tapered	-2.62150	0.652
Square Tapered	Square	Tapered	5.30225	0.426
		Ovoid	5.41708	0.412
	Tapered	Square	-5.30225	0.426
		Ovoid	0.11483	1.000
	Ovoid	Square	-5.41708	0.412
		Tapered	-0.11483	1.000
Tapered	Square	Tapered	4.08733	0.464
		Ovoid	13.15075*	**0.004**
	Tapered	Square	-4.08733	0.464
		Ovoid	9.06342*	**0.042**
	Ovoid	Square	-13.15075*	**0.004**
		Tapered	-9.06342*	**0.042**
Ovoid	Square	Tapered	2.65967	0.673
		Ovoid	7.18225	0.084
	Tapered	Square	-2.65967	0.673
		Ovoid	4.52258	0.337
	Ovoid	Square	-7.18225	0.084
		Tapered	-4.52258	0.337

*. The mean difference is significant at the 0.05 level.

TABLE 16:

COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN DENTULOUS FEMALE BY DESCRIPTIVE STATISTICS:

Facial form	Arch form	N	Mean	Std. Deviation	Minimum	Maximum
Square	Square	6	39.1751	4.86104	31.94	44.14
	Tapered	6	34.8676	5.99930	26.54	40.92
	Ovoid	6	27.9352	3.06290	24.57	33.55
	Total	18	33.9926	6.55704	24.57	44.14
Square Tapered	Square	6	38.2563	6.06446	26.72	43.76
	Tapered	6	33.6013	4.87495	28.32	41.52
	Ovoid	6	32.2806	2.72973	27.96	36.31
	Total	18	34.7128	5.19172	26.72	43.76
Tapered	Square	6	34.0157	3.80458	29.02	37.88
	Tapered	6	31.4902	3.02980	27.10	34.86
	Ovoid	6	29.3439	3.68208	23.77	32.82
	Total	18	31.6166	3.84769	23.77	37.88
Ovoid	Square	6	33.4032	2.29982	30.50	35.99
	Tapered	6	27.9583	4.45209	22.19	31.97
	Ovoid	6	26.8384	3.75635	21.27	32.48
	Total	18	29.4000	4.49899	21.27	35.99

TABLE 17:

COMPARISON OF MEAN BITE FORCE BETWEEN AND WITHIN FACIAL FORMS IN DENTULOUS FEMALE BY ONE WAY ANOVA

Facial form-mean bite force		Sum of Squares	df	Mean Square	F	**Sig.**
Square	Between Groups	385.897	2	192.949	8.389	**0.004**
	Within Groups	345.013	15	23.001		
	Total	730.910	17			
SquareTapered	Between Groups	118.246	2	59.123	2.609	0.107
	Within Groups	339.971	15	22.665		
	Total	458.217	17			
Tapered	Between Groups	65.619	2	32.810	2.645	0.104
	Within Groups	186.061	15	12.404		
	Total	251.681	17			
Ovoid	Between Groups	147.993	2	73.996	5.660	**0.015**
	Within Groups	196.102	15	13.073		
	Total	344.095	17			

TABLE 18:

MULTIPLE COMPARISON OF MEAN BITE FORCE BETWEEN DIFFERENT ARCH FORMS FOR THE RESPECTIVE FACIAL FORMS IN DENTULOUS FEMALE BY TUKEY HSD-POST HOC TEST

Facial form	(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
Square	Square	Tapered	4.30750	0.294
		Ovoid	11.23992*	**0.003**
	Tapered	Square	-4.30750	0.294
		Ovoid	6.93242	0.060
	Ovoid	Square	-11.23992*	**0.003**
		Tapered	-6.93242	0.060
Square Tapered	Square	Tapered	4.65500	0.240
		Ovoid	5.97575	0.108
	Tapered	Square	-4.65500	0.240
		Ovoid	1.32075	0.881
	Ovoid	Square	-5.97575	0.108
		Tapered	-1.32075	0.881
Tapered	Square	Tapered	2.52542	0.448
		Ovoid	4.67175	0.087
	Tapered	Square	-2.52542	0.448
		Ovoid	2.14633	0.555
	Ovoid	Square	-4.67175	0.087
		Tapered	-2.14633	0.555
Ovoid	Square	Tapered	5.44483*	0.049
		Ovoid	6.56475*	**0.017**
	Tapered	Square	-5.44483*	0.049
		Ovoid	1.11992	0.855
	Ovoid	Square	-6.56475*	**0.017**
		Tapered	-1.11992	0.855

*. The mean difference is significant at the 0.05 level.

TABLE 19:

GENDER COMPARISON OF MEAN BITE FORCE FOR EDENTULOUS SUBJECTS BY GROUP STATISTICS

Significance was found by Independent samples t Test.

Facial form	Arch form	Gender	Mean± Std. Deviation	P value
Square	Square	Male	6.91±0.75	**0.000**
		Female	4.39±0.55	
	Tapered	Male	6.14±0.67	**0.000**
		Female	4.31±0.16	
	Ovoid	Male	4.68±0.49	**0.000**
		Female	2.84±0.70	
Square Tapered	Square	Male	6.05±0.91	**0.000**
		Female	3.90±0.37	
	Tapered	Male	5.33±0.78	**0.002**
		Female	3.97±0.26	
	Ovoid	Male	3.62±0.96	0.446
		Female	3.27±0.51	
Tapered	Square	Male	5.39±0.36	**0.000**
		Female	3.39±0.25	
	Tapered	Male	4.92±0.43	**0.001**
		Female	3.57±0.49	
	Ovoid	Male	4.54±0.66	**0.001**
		Female	3.15±0.23	
Ovoid	Square	Male	4.50±0.98	**0.005**
		Female	3.01±0.32	
	Tapered	Male	4.51±0.94	**0.002**
		Female	2.68±0.50	
	Ovoid	Male	3.75±0.42	0.244
		Female	3.03±01.36	

TABLE 20:

GENDER COMPARISON OF BITE FORCE FOR DENTULOUS SUBJECTS BY GROUP STATISTICS

Significance was found by Independent samples t Test.

Facial form	Arch form	Gender	Mean± Std. Deviation	P value
Square	Square	Male	47.93±6.68	**0.027**
		Female	39.17±4.86	
	Tapered	Male	43.39±4.94	**0.023**
		Female	34.86±5.99	
	Ovoid	Male	40.77±2.83	**0.000**
		Female	27.93±3.06	
Square tapered	Square	Male	43.19±7.07	0.224
		Female	38.25±6.06	
	Tapered	Male	37.89±7.69	0.276
		Female	33.60±4.87	
	Ovoid	Male	37.77±6.68	0.092
		Female	32.28±2.72	
Tapered	Square	Male	44.71±5.32	**0.002**
		Female	34.01±3.80	
	Tapered	Male	40.62±6.00	**0.008**
		Female	31.49±3.02	
	Ovoid	Male	31.56±6.14	0.465
		Female	29.34±3.68	
Ovoid	Square	Male	38.68±4.99	**0.041**
		Female	33.40±2.29	
	Tapered	Male	36.02±5.52	**0.019**
		Female	27.95±4.45	
	Ovoid	Male	31.50±5.55	0.119
		Female	26.83±3.75	

TABLE 21:

BITE FORCE COMPARISON BETWEEN DENTULOUS AND EDENTULOUS MALE BY GROUP STATISTICS

Significance was found by Independent samples t Test.

Facial form	Arch form		Mean± Std. Deviation	P value
Square	Square	Dentulous	47.93±6.68	**0.000**
		Edentulous	6.91±0.75	
	Tapered	Dentulous	43.39±4.94	**0.000**
		Edentulous	6.14±0.67	
	Ovoid	Dentulous	40.77+2.83	**0.000**
		Edentulous	4.68+0.49	
Square tapered	Square	Dentulous	43.19±7.07	**0.000**
		Edentulous	6.05±0.91	
	Tapered	Dentulous	37.89±7.69	**0.000**
		Edentulous	5.33±0.78	
	Ovoid	Dentulous	37.77±6.68	**0.000**
		Edentulous	3.62±0.96	
Tapered	Square	Dentulous	44.71±5.32	**0.000**
		Edentulous	5.39±0.36	
	Tapered	Dentulous	40.62±6.00	**0.000**
		Edentulous	4.92±0.43	
	Ovoid	Dentulous	31.56±6.14	**0.000**
		Edentulous	4.54±0.66	
Ovoid	Square	Dentulous	38.68±4.99	**0.000**
		Edentulous	4.50±0.98	
	Tapered	Dentulous	36.02±5.52	**0.000**
		Edentulous	4.51±0.94	
	Ovoid	Dentulous	31.50±5.55	**0.000**
		Edentulous	3.75±0.42	

Table 22:

BITE FORCE COMPARISON BETWEEN DENTULOUS AND EDENTULOUS FEMALE BY GROUP STATISTICS

Significance was found by Independent samples t Test.

Facial form	Arch form		Mean± Std. Deviation	P value
Square	Square	Dentulous	39.17±4.86	**0.000**
		Edentulous	4.39±0.55	
	Tapered	Dentulous	34.86±5.99	**0.000**
		Edentulous	4.31±0.16	
	Ovoid	Dentulous	27.93±3.06	**0.000**
		Edentulous	2.84±0.70	
Square tapered	Square	Dentulous	38.25±6.06	**0.000**
		Edentulous	3.90±0.37	
	Tapered	Dentulous	33.60±4.87	**0.000**
		Edentulous	3.97±0.26	
	Ovoid	Dentulous	32.28±2.72	**0.000**
		Edentulous	3.27±0.51	
Tapered	Square	Dentulous	34.01±3.80	**0.000**
		Edentulous	3.39±0.25	
	Tapered	Dentulous	31.49±3.02	**0.000**
		Edentulous	3.57±0.49	
	Ovoid	Dentulous	29.34±3.68	**0.000**
		Edentulous	3.15±0.23	
Ovoid	Square	Dentulous	33.40±2.29	**0.000**
		Edentulous	3.01±0.32	
	Tapered	Dentulous	27.95±4.45	**0.000**
		Edentulous	2.68±0.50	
	Ovoid	Dentulous	26.83±3.75	**0.000**
		Edentulous	3.03±1.36	

INTERPRETATION OF RESULTS

COMPARISON OF MEAN BITE FORCE IN DIFFERENT FACIAL FORMS OF THE SUBGROUPS:

Table 1 shows the comparison of mean bite force in different facial forms among all the subgroups.

Square and Ovoid facial form have the greatest and least mean bite force respectively and the difference is statistically significant ($p<0.05$) **(Table 2).**

On individual comparison **(Table 3,4,5,6)**

i. **Dentulous Male**: mean difference was found to be statistically significant between Square and Ovoid facial forms (p=0.001).

ii. **Dentulous Female**: mean difference was found to be statistically significant between :

Square and Ovoid facial forms (p=0.044)

Square tapered and Ovoid facial forms (p=0.014)

iii. **Edentulous Male**: mean difference was found to be statistically significant between :

Square and Square tapered facial forms (p=0.045)

Square and Tapered facial forms (p=0.031)

Square and Ovoid facial forms (p=0.000)

iv. **Edentulous Female**: mean difference was found to be statistically significant between :

Square and Ovoid facial forms (p=0.001)

Square tapered and Ovoid facial forms (p=0.004)

COMPARISON OF MEAN BITE FORCE IN EDENTULOUS MALE SUBGROUP:

Table 7 shows the comparison of mean bite force between different arch forms for the respective facial forms in edentulous male subgroup.

i. In Square facial form, the mean bite force was found to be:

Square Arch form (6.91±0.75) > Tapered Arch form (6.14±0.67) > Ovoid Arch form (4.68±0.49).

This difference was statistically significant (p=0.000) (**Table 8**). On individual comparison (**Table 9**), statistically significant mean difference was found between Square and Ovoid arch forms (p=0.000) and Tapered and Ovoid arch forms (p=0.004).

ii. In Square tapered facial form, the mean bite force was found to be:

Square Arch form (6.05±0.91) > Tapered Arch form (5.33±0.78) > Ovoid Arch form (3.62±0.96).

This difference was statistically significant p=0.001 (**Table 8**). On individual comparison (**Table 9**), statistically significant mean difference was found between Square and Ovoid arch forms (p=0.001) and Tapered and Ovoid arch forms (p=0.012).

iii. In Tapered facial form, the mean bite force was found to be:

Square Arch form (5.39±0.36) > Tapered Arch form (4.92±0.43) > Ovoid Arch form (4.54±0.66).

This difference was statistically significant (p=0.034) (**Table 8**). On individual comparison (**Table 9**), statistically significant mean difference was found between Square and Ovoid of the arch forms (p=0.027).

iv. In Ovoid facial form, the mean bite force was found to be:

Tapered Arch form (4.51±0.94) > Square Arch form (4.50±0.98) > Ovoid Arch form (3.75±0.42).

However, this difference was not statistically significant (p=0.221) (**Table 8**). Even on individual comparison (**Table 9**), no statistically significant mean difference was found between any of the arch forms.

COMPARISON OF MEAN BITE FORCE IN EDENTULOUS FEMALE SUBGROUP:

Table 10 shows the comparison of mean bite force between different arch forms for the respective facial forms in edentulous female subgroup:

i. For the Square facial form, the mean bite force was found to be:

Square arch form (4.39±0.55) > Tapered arch form (4.31±0.16) > Ovoid arch form (2.84±0.70).

This difference was statistically significant p=0.000 (**Table 11**). On individual comparison (**Table 12**), statistically significant mean difference was found between Square and Ovoid arch forms (p=0.000) and Tapered and Ovoid arch forms (p=0.001).

ii. For Square Tapered facial form, the mean bite force was found to be:

Tapered arch form (3.97±0.26) > Square arch form (3.90±0.37) > Ovoid arch form (3.27±0.51).

This difference was statistically significant p=0.014 (**Table 11**). On individual comparison (**Table 12**), statistically significant mean difference was found between Square and Ovoid arch forms (p=0.036) and Tapered and Ovoid arch forms (p=0.020)

iii. For Tapered facial form, the mean bite force was found to be:

Tapered arch form (3.57±0.49) followed by Square arch form (3.39±0.25) and Ovoid arch form (3.15±0.23).

However, this difference was not statistically significant p=0.152 (**Table 11**). Even, on individual comparison (**Table 12**), no statistically significant mean difference was found between any of the arch forms.

iv. For Ovoid facial form, the mean bite force was found to be:

Ovoid arch form (3.03±1.36) > Square arch form (3.01±0.32) > Tapered arch form (2.68±0.50).

However, this difference was not statistically significant p=0.744 (**Table 11**). Even, on individual comparison (**Table 12**), no statistically significant mean difference was found between any of the arch forms.

COMPARISON OF MEAN BITE FORCE IN DENTULOUS MALE SUBGROUP:

Table 13 shows the comparison of mean bite force between different arch forms for the respective facial forms in dentulous male subgroup.

i. For Square Facial form, the mean bite force was found to be:

Square arch form (47.93±6.68) > Tapered arch form (43.39±4.94) > Ovoid arch form (40.77±2.83).

However, this difference was not statistically significant p=0.077 (**Table 14**). Even on individual comparison (**Table 15**), no statistically significant mean difference was found between any of the arch forms.

ii. For Square Tapered Facial form, the mean bite force was found to be:

Square arch form (43.19±7.07) > Tapered arch form (37.89±7.69) > Ovoid arch form (37.77±6.68).

However, this difference was not statistically significant p=0.352 (**Table 14**). Even on individual comparison (**Table 15**), no statistically significant mean difference was found between any of the arch forms.

iii. For Tapered Facial form, the mean bite force was found to be:

Square arch form (44.71±5.32) > Tapered arch form (40.62±6.00) > Ovoid arch form (31.56±6.14).

This difference was statistically significant (p=0.004) (**Table 14**). On individual comparison (**Table 15**), statistically significant mean difference was found between Square and Ovoid arch forms (p=0.004) and Tapered and Ovoid arch forms (p=0.042).

iv. For Ovoid Facial form, the mean bite force was found to be:

Square arch form (38.68±4.99) > Tapered arch form (36.02±5.52) > Ovoid arch form (31.50±5.55).

However, this difference was not statistically significant (p=0.096) (**Table 14**). Even on individual comparison (**Table 15**), no statistically significant mean difference was found between any of the arch forms.

COMPARISON OF MEAN BITE FORCE IN DENTULOUS FEMALE SUBGROUP:

Table 16 shows the comparison of mean bite force between different arch forms for the respective facial forms in dentulous female subgroup.

i. For Square Facial form, the mean bite force was found to be:

Square arch form (39.17±4.86) > Square Tapered arch form (34.86±5.99) > Ovoid arch form (27.93±3.06).

This difference was statistically significant (p=0.004) (**Table 17**). On individual comparison (**Table 18**), statistically significant mean difference was found between Square and Ovoid facial forma (p=0.003).

ii. For Square Tapered Facial form, the mean bite force was found to be: **Square arch form (38.25±6.06) > Tapered arch form (33.60±4.87) > Ovoid arch form (32.28±2.72).**

However, this difference was not statistically significant (p=0.107) (**Table 17**). Even on individual comparison (**Table 18**), statistically significant mean difference was not found between any of the facial forms (p>0.05).

iii. For Tapered Facial form, the mean bite force was found to be:

Square arch form (34.01±3.80) > Tapered arch form (31.49±3.02) > Ovoid arch form (29.34±3.68).

However, this difference was not statistically significant (p=0.104) (**Table 17**). Even on individual comparison (**Table 18**), statistically significant mean difference was not found between any of the facial forms (p>0.05).

iv. For Ovoid Facial form, the mean bite force was found to be:

Square arch form (33.40±2.29) > Tapered arch form (27.95±4.45) > Ovoid arch form (26.83±3.75).

This difference was statistically significant (p=0.015) (**Table 17**). On individual comparison (**Table 18**), statistically significant mean difference was found between Square and Tapererd facial forms (p=0.049) and Square and Ovoid facial forms (p=0.017).

GENDER COMPARISON OF MEAN BITE FORCE IN THE EDENTULOUS SUBJECTS:

Table 19 shows the comparison of mean bite force between males and females in edentulous subjects.

Males had significantly greater bite force than females in all types of facial forms and arch forms ($p \leq 0.05$) except in:

i. Square Tapered facial form with Ovoid arch form(p= 0.446)
ii. Ovoid facial form with Ovoid arch form.(p =0.224)

GENDER COMPARISON OF MEAN BITE FORCE IN THE DENTULOUS SUBJECTS:

Table 20 shows the comparison of mean bite force between males and females in dentulous subjects.

Males had significantly greater bite force than females in all types of facial forms and arch forms ($p \leq 0.05$) except:

i. Square arch form in Square Tapered facial form (p=0.224).
ii. Tapered arch form in Square Tapered facial form (p=0. 276).
iii. Ovoid arch form in Square Tapered facial form (p=0.092).
iv. Ovoid arch form in Tapered facial form (p=0.465).
v. Ovoid arch form in Ovoid facial form (p=0.119).

MEAN BITE FORCE COMPARISON BETWEEN DENTULOUS AND EDENTULOUS MALE SUBGROUPS:

Table 21 shows the comparison of mean bite force between the edentulous and dentulous male subgroups.

Statistically significant mean difference (p=0.000) was found between dentulous and edentulous males in all types of facial forms and arch forms.

MEAN BITE FORCE COMPARISON BETWEEN DENTULOUS AND EDENTULOUS FEMALE SUBGROUPS:

Table 22 shows the comparison of mean bite force between the edentulous and dentulous female subgroups.

Statistically significant mean difference (p=0.000) was found between dentulous and edentulous females in all types of facial forms and arch forms.

Fig.23 COMPARISON OF MEAN BITE FORCE AMONG EDENTULOUS SUBJECTS

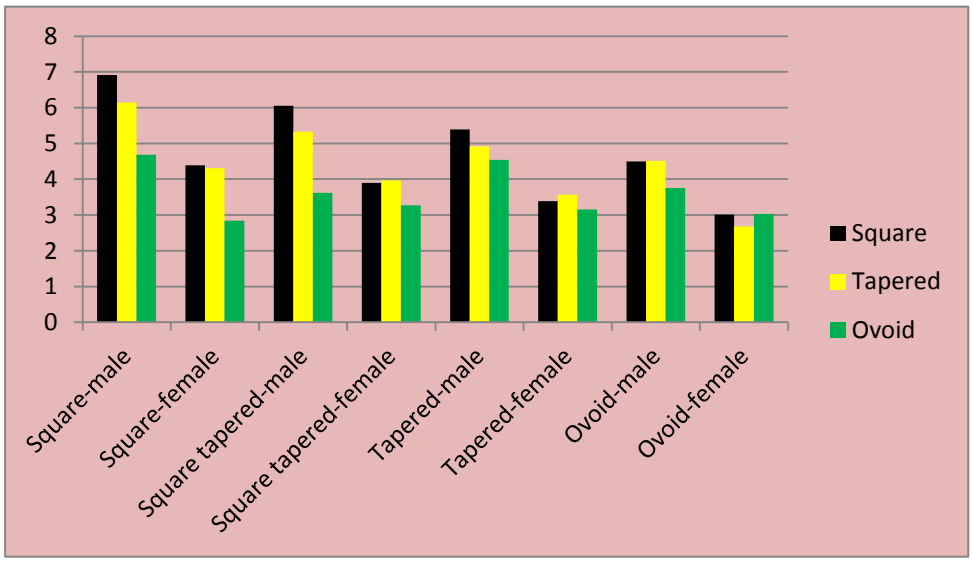


Fig.24 COMPARISON OF MEAN BITE FORCE AMONG DENTULOUS SUBJECTS

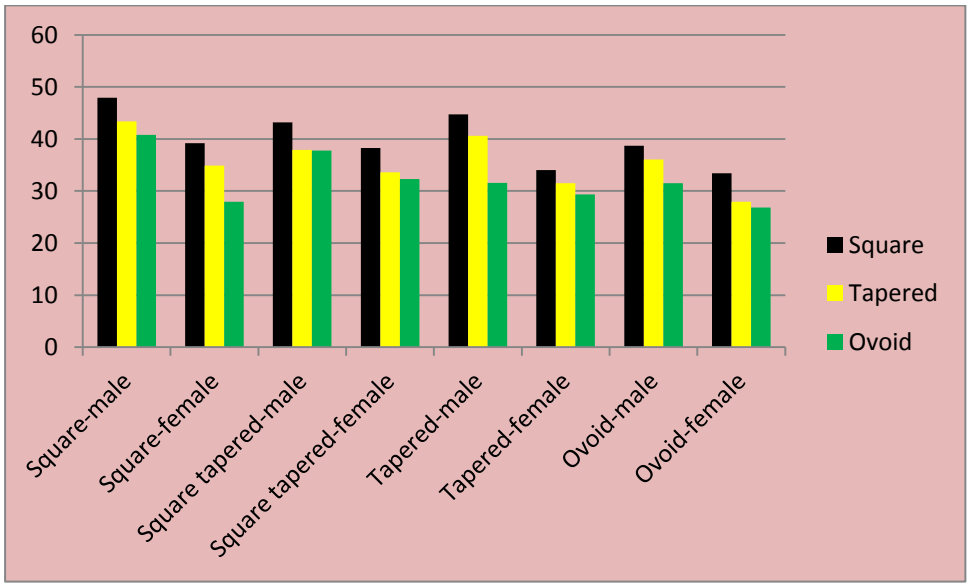


Fig.25 COMPARISON OF MEAN BITE FORCE BETWEEN EDENTULOUS AND DENTULOUS MALE SUBGROUPS.

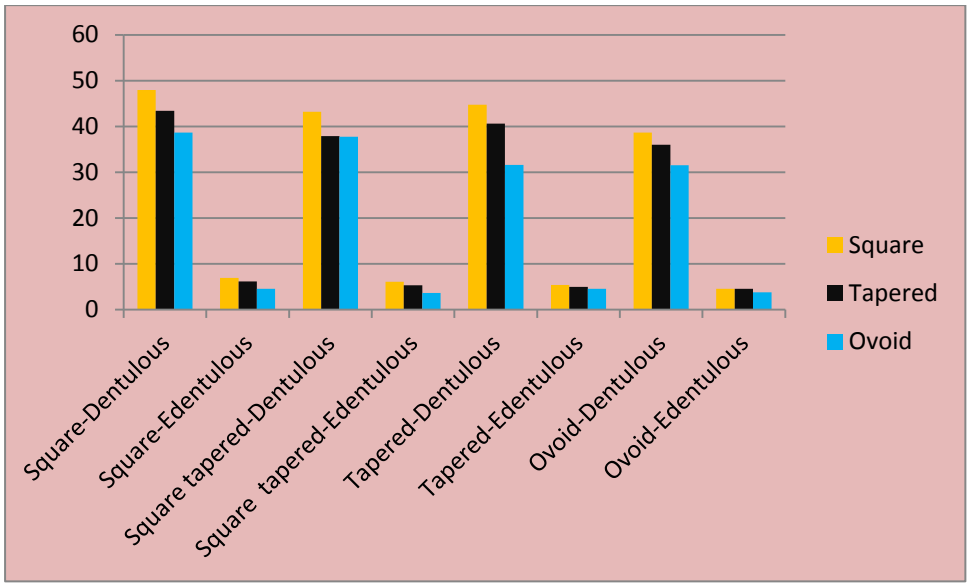
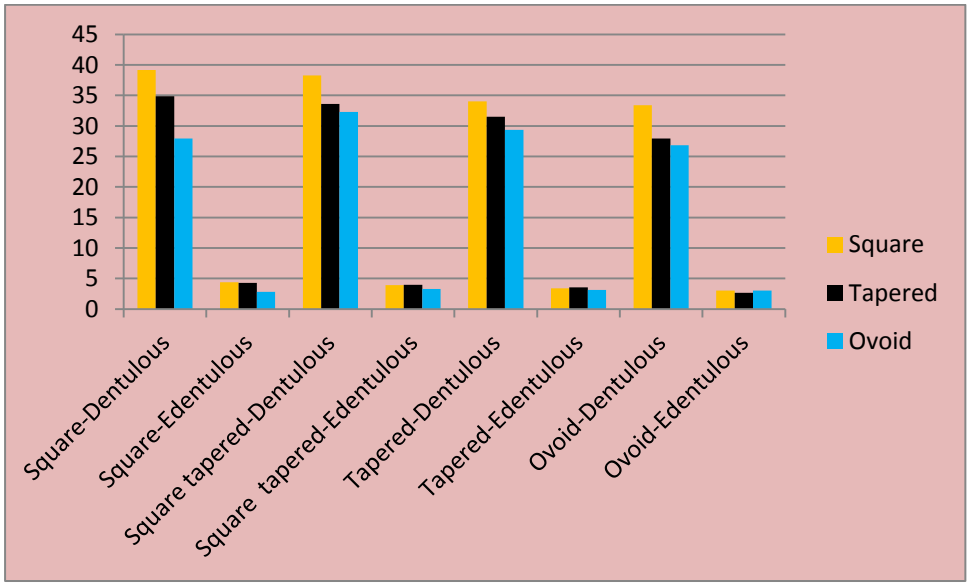


Fig.26 COMPARISON OF MEAN BITE FORCE BETWEEN EDENTULOUS AND DENTULOUS FEMALE SUBGROUPS.



DISCUSSION

DISCUSSION :

Chewing or occlusion is a phenomenon of interaction between the teeth, bones and muscles of maxilla and mandible. This process is also known as mastication and the force acting during this process is known as the masticatory force or biting force[4]. This force is created during the physiological act of chewing by the dynamic action of the masticatory system. Hatch et al [48] have reported that the bite force is one of the key determinants of efficiency of masticatory performance.

The knowledge of individual bite force helps dentist in understanding different types of dentition, the mechanics of mastication, to evaluate the physiological characteristics of jaw muscles and in the diagnosis and treatment of temporomandibular disorders. A great deal of information regarding the mechanical properties of stomatognathic system is obtained from occlusal forces. A correct selection of biomaterials to restore the masticatory organ function requires consideration of the mechanical status of the mandible[55].

In Prosthodontics, bite force helps in designing of prosthesis, in material selection, deciding the number of occlusal contacts needed to avoid excessive force on the underlying structure, in ascertaining the therapeutic effect of prosthetic devices, and more importantly, as a reference value for studies on the biomechanics of prosthetic devices[5].

There are many factors that influence the magnitude of the biting force of an individual. These factors can be categorized into subject related factors and subject-device related factors[2, 56, 57].

SUBJECT RELATED FACTORS	SUBJECT-DEVICE RELATED FACTORS
• Age • Gender • Body mass index • Craniofacial morphology • Temporo-mandibular disorders and pain. • Dental and periodontal status • Psychological factors	• Type of recording devices • Amount of jaw separation as determined by the thickness of the bite force measuring device • Type of measurement (anterior or posterior and unilateral or bilateral) • Device position • Patient position

Bakke et al[33], Shinogaya et al[58], Ferrario et al[59], Wieslaw et al [55] and many others have found that bite force is positively related to age and gender. Studies have found that the long-faced type of morphology has been associated with smaller bite force values [60, 61]. Cephalometric studies on the effect of craniofacial morphology and bite force have shown that short faced individuals have greater bite force than normal faced individuals and long faced ones[28]. Transverse facial dimensions have also been demonstrated to have a direct relationship with bite force[64]. A negative correlation between bite force and mandibular inclination has been found by Pereira et al[62] .

Relationship of maximum bite force to facial form has been evaluated and established in the natural dentition [14, 65]. Similar study has been performed by Gaurav et al[10] in completely edentulous subjects.

Facial form has been found to be related to the arch form of the individual [15]. Only one study [14] has been conducted so far to evaluate and establish the link between arch form and bite force. They concluded that the arch form-bite force relationship was not significant.

Complete denture wearers generally have a lower chewing efficiency when compared with normal individuals with full natural dentition. This functionally impairs their maximum bite force to about five to six times lesser than the dentulous individuals. As very few studies are available on the effect of facial form and arch form on bite force in completely edentulous subjects, this study was formulated to investigate their relationship.

Currently, there are two types of bite force measuring techniques available i.e. Direct and Indirect. Direct techniques include the use of a suitable transducer placed between a pair of teeth. It is a convenient way to measure the bite force. In the indirect method, functional relationship between the bite force and physiological variables is evaluated as these variables are known to be functionally related to the bite force[66].

DIRECT METHODS	INDIRECT METHOD
• Gnathodynamometer • Lever-spring • Manometer-spring and lever • Micrometered Devices • Electronic transducers • Loadcells • Strain gauges • Digital occlusal force-meters • Pressure sensitive foils • Pressure transducers • Digital dynamometers • Quart force transducer • Dental Prescale System	• Electromyography

Apart from physiological and pathological factors, the parameters associated with measuring methodologies such as the mechanical characteristics of the bite force recording system affect the bite force[67]. Direct methods are convenient and accurate in determining the individual bite force but it requires sophisticated instrumentation and intervention whereas the indirect methods require investigation of physiological parameters and are not accurate.

Strain gauge is a bite force measuring device consisting of metal beams connected to Wheatstone bridges. A change in the resistance changes the output voltage[68]. It is available in different widths and heights and can be customized according to the specific needs.

Strain-gauge tranducers have been used by Manly and Vinton[11], Lindqvist and Ringqvist[69], Linderholm and Wennström [13] and many others. All modern instruments function based on the electrical resistance action of strain gauges[2]. Force levels of 50-800 N with accuracy of 10 N and 80% precision can be recorded by most of them [5]. Strain gauge transducers are the most widely accepted bite force measuring devices[45, 70-76].

Bite Force Sensor HE 6210, a customized strain gauge transducer (Hariom electronics, Gujarat) used in this study works on Wheatstone Bridge principle. The two probes (the sensing elements) of the transducer are made of heat-treated alloy tool steel construction. The sensing probe consists of strain gauges. A total of four strain gauges were used to form the Wheatstone bridge, which has four connections.

On loading there is a change in the resistance that changes the output voltage. The device is connected to a weight indicator which converts the voltage into weight and the red led displays the value. The device is configurated to measure the

bite force values in Kilogram Force (the gravitational metric unit of force; 1KgF=9.806 N). It has a maximum force bearing capacity of 80 KgF and a sensitivity of 0.005. The strain gauge transducer is 10mm in height, 16 mm in width with a force bearing probe length of 40mm.

Owing to their easy handling properties, relatively simple installation techniques, precision in recording the fluctuating strain encountered inside the oral cavity, response to fluctuating as well as static strain and easily recordable output signals and cost effectiveness, electrical strain gauge is the most commonly preferred device for bite force measurements.

Electronic devices available today give a very sensitive result but they are very expensive and complicated. Therefore, devices based on mechanical principles have retained their validity[1].

Biologic development occurs based on general symmetric pattern. Function, trauma and disease modify the structural symmetry and various magnitudes of asymmetry may develop in the two halves. Hence, a perfect bilateral symmetry is seldom found in nature [77]. All subjects in this study had normal appearance with no obvious deformity or asymmetry. Subjects with history of trauma, surgery or orthodontic treatment were thus excluded.

Bite force varies with Angle's class I, class II and III molar relationship [80]. Dental fillings, position and the number of teeth and dentures are important factors in the value of the bite force[81]. Kampe et al[82] have found that the subjects with dental fillings have shown significantly lower bite force in the incisor region.

Shi[84], Kroon and Naeije[85], Buchner et al[86] and Svensson et al[87] have concluded that bite force is limited by orofacial pain an temporomandibular disorders.

Individuals with sleep bruxism can exhibit clinical signs such as tooth wear, periodontal diseases and temporomandibular disorders[104, 105]. In some patients pain decreases the EMG activity of masticatory muscles[106].

Patients with periodontal diseases were found to have a reduced masseter muscle size, implicating in reduced capability in producing higher bite force[88].

Thus, dentulous subjects were chosen with full natural dentition (excluding third molars) in Angle's class I molar relationship. Those with any kind of restorations, missing teeth, prosthesis, periodontal diseases and history of bruxism, orthognathic surgery, orthodontic treatment or TMJ disorders were excluded from the study.

Lasilla et al [79] also found decreased bite force in regions of negative alveolar process and thus stated that a positive correlation existed between the bite force and height of the alveolar process. Thus, completely edentulous subjects with flabby or resorbed ridges were excluded.

Many methods have been used in assessing the facial form. Facial index = (nasion-gnathion distance) / zygomatic breadth (distance between two zygomas) classifies face types as euryprosopic, mesoprosopic and leptoprosopic. House classified facial form into square, square tapered, tapered and ovoid. House and loop classified facial form into square, tapered and ovoid. House classification was adopted in this study as was done in previous studies[10, 14, 65].

Standardized digital photography, an inexpensive technique suggested and applied by Shivani et al [77], Mortaza et al[65] and Gaurav et al[10] has been applied in this study. Positioning of the camera at the patient's eye level and at a common distance with Frankfort horizontal plane nearly parallel to floor was made according to Duygu et al[53]. Facial midline and two vertical lines on the outer contour of the face were drawn. Facial form was then assessed based on the vertical lines and facial outline according to Gaurav et al [10] and Mortaza et al [65].

Chuck[90] has classified arch forms into square, tapered and ovoid. Researchers have applied mathematical functions for representing dental arch form. Parabola, ellipse[107] or a catenary curve[108] have been applied to dental arch analysis. Arch form was classified as suggested by Sanjna et al[15] and Veena et al[14]. By determining the distance between the intercanine line to incisal surface of maxillary central incisor, the position of central incisors and canines were determined. The arch form with central incisors nearly in a line with the canines was termed as square arch form; while that at a greater distance forward from the canines were termed as tapered arch. The arch form with central incisors forward of canines in positions between that of square and tapered arch was termed as ovoid arch [91]. Arch form has been classified in the same manner in this study.

Patient was reviewed at 24 hr, 1 week and1 month interval after complete denture insertion in order to correct occlusal prematurities. The patient was allowed adequate time to acquaint and accustom to the new prosthesis before commencing bite force measurement.

Before recording the subject's bite force, the device was calibrated using known weights of 1kg, 2 kg and 5 kg as suggested in earlier studies to ensure accurate

measurement devoid of any instrumental errors[68].

The patient was seated upright, eyes forward and occulsal surface of the maxillary denture (maxillary teeth in dentulous subjects) parallel to the floor as suggested by Tingey et al[92] since the head and body positions affect the bite force measurement.

Bite force varies in different areas of the oral cavity[59]. Greater bite force has been recorded when the transducer is placed more posteriorly in the dental arch[41]. It is explained by the lever mechanics of the jaw[66, 98]. In addition, because of larger area and periodontal ligament around roots of posterior teeth, greater bite force can be better tolerated by them[41].

Different positions of the transducer may influence different muscles involved in the force production. If placed anteriorly between the incisor teeth, resulting in mandibular protrusion, the masseter muscle together with the medial pterygoid muscle will produce most of the force. When placed more posteriorly, the anterior fibres of temporalis muscle becomes more active and results in a greater contribution to the effort[41].

Pivolva et al[93] reported that ,in the denture wearers, the second premolar carried the heaviest load, resulting in proper stabilization of the denture base during function without creating much pressure on the temporomandibular joint. Thus, the strain gauge transducer was positioned in the second premolar and first molar region in the edentulous patients.

Korioth and Hannam[94] concluded that greater bite forces were evident at the posterior most tooth locations. The highest bite force values recorded on molar teeth

reflected the form, elasticity and complex bending properties of the mandible. Wieslaw et al [55] demonstrated a bite force of 606 N in males and 433 N in females in first molar region and 628 N in males and 450N in females in the second molar region, which were the greatest forces compared to the rest of the teeth. Therefore, first and second molar region was chosen as the bite force recording site in dentate subjects.

Any increase in the vertical dimension may alter the length of the jaw elevator muscles and the position of mandibular head in the temporalis fossa and the masticatory function and bite force[52]. Lindauer et al[95] , Mackenna et al [96] and Manns et al[97] indicate that the strongest bite force has been recorded between 15 and 20 mm of jaw separation anteriorly. In this study, the transducer was made 14mm thick (10 mm transducer +two 2 mm thick thermoplastic sheet) so that when the subject bites, the mouth opening measured between incisors would be within the limits mentioned by previous studies.

Another influencing factor for the magnitudes of bite force is the side involved in recording: whether it is unilateral or bilateral recording. Many studies have concluded that bite force recorded during bilateral clenching is larger than unilateral clenching[33, 58, 67, 99]. The lower bite force and jaw muscle activity on clenching unilaterally may be due to inhibition by periodontal and joint receptors. Inhibition by periodontal receptors prevent excessively strong bite forces and high muscle activities in order to avoid damage to the teeth.

In denture patients, a bilateral transducer does not reflect normal function as they do not distribute the occlusal forces symmetrically during chewing and biting.

In this study, unilateral measurement was made as Van Der Bilt et al[67] pointed out that masseter activity did not show significant differences in unilateral clenching.

On biting the hard metal surface of the transducer, subject's neuromuscular reaction generates irregular movements preventing maximum bite force. Tortopidis et al[41] used acrylic appliances to be in contact with the metal portion of the strain-gauge transducers to minimize the risk of teeth fracture when biting hard on the transducer. Acrylic splints offer a comfortable biting surface[5, 41]. Kleinfelder and Ludwig[101] concluded that the use of acrylic splints increases the bite force values.

In this study, Bite force sensor's probes were covered by a 2mm thick thermoplastic sheet similar to Mortaza et al[65] and Gaurav et al[10]. Disposable sleeves were used to prevent salivary contamination, to prevent short circuits and to measure strain correctly as suggested by previous studies[102].

An interval of at least one minute was allowed to elapse between each recording as previously proved in earlier studies[103], to provide enough time for strain gauge to revert to zero balance after loading.

Recording of bite force was repeated for 2 to 3 times until the subjects got acquainted with the device and the method. Finally, the mean of right and left side maximum bite force value was taken for the statistical analysis in both the groups.

In this study, males had a greater bite force than females. Significant difference was found in mean bite force values between males and females in most of the completely edentulous and the dentulous subjects which was in accordance with the previous studies [33, 39, 55]. Their greater muscular potential has been suggested to be attributed by the anatomic differences[109, 110]. They have type 2 fibers in masseter

muscles with larger diameter and greater sectional area than those of the females. Hormonal differences might be a contributing factor to the composition of the muscle fibers[111]. Ferrario et al[59] explained that males had larger dental size resulting in larger periodontal ligament and thus resulted in greater bite force.

Results revealed statistically significant difference between mean maximum bite force of completely edentulous and dentulous subjects. Edentulous patients had only one –seventh or less bite force than that of the dentulous counterparts. Atrophy of the jaw-closing muscles is suggested to be the main reason for the reduced bite force. With age the cross-sectional areas of the muscles- masseter and medial pterygoid showed a more significant reduction in edentulous subjects[63]. The force with which the jaw closes declines beyond 50 years[4].

Similar results were concluded by Miyaura et al[78] who showed that the biting force values have been found to be 11, 35and 80 % for complete denture groups, removable partial denture and fixed partial dentures respectively. Wennstrom[21] has reported that the denture wearers had only one-fifth the bite force of healthy dentition individuals. Heath[27] concluded that complete denture wearers had a masticatory efficiency of 16% to 50% as that of dentate subjects.

In all the subgroups of this study, the greatest and least mean maximum bite force was recorded by Square facial form and Ovoid facial form respectively. This has been explained by the reason that in Square facial forms, elevator muscles exhibit greater mechanical advantage with a more vertical ramus and acute gonial angle[4,39,60,61,112]. Tapering and ovoid facial forms were not significant as the lower part of the face becomes converging. The significance of Square tapered facial form

in dentulous and edentulous females could be because of their intermediary pattern between the highly converged Tapered and Ovoid facial forms and the near- parallel Square facial form. Bite force has thus been found to reflect the geometry of lever mechanism of mandible.

The results in this study show that the bite force was found to be greatest for the Square arch form and least for the Ovoid arch form, in most of the facial forms of the subgroups. This pattern is similar to the bite force based on their facial form. A study by Sanjna et al[15] had concluded that predominant upper arch form in leptoprosopic faces was Square whereas in mesoprosophic faces it was Ovoid. It has also been postulated that facial type can determine arch form[28, 59].

There were exceptions to the above pattern:

Tapered arch form had a greater bite force in:

1. Ovoid facial form of edentulous male subgroup
2. Square tapered and Tapered facial forms of edentulous female subgroup and
3. Tapered facial form of dentulous female subgroup.

Ovoid arch form had a greater bite force in:

1. Ovoid facial forms of edentulous female subgroup

This difference could have been attributed by other factors affecting bite force such as the thickness of masseter and temporal muscles and psychological status of the individual.

Although there are many advantages, the disadvantage of discomfort and fear of damage to teeth persists with the usage of strain gauge device.

The facial dimension was measured only from the anterior aspect. Cephalometric measurements and transverse dimensions of face were not taken into account. But these two parameters can also influence the bite force.

This is a preliminary institutional study with a smaller sample size and restricted population. Hence, more studies need to be conducted on a larger scale applying recent devices to compare and evaluate the results obtained in this study.

SUMMARY
&
CONCLUSION

SUMMARY:

This study was aimed at determining the maximum bite force in completely edentulous patients rehabilitated with complete denture prosthesis based on their gender, facial form and arch form.

The 288 samples comprised of two groups of 144 completely edentulous patients and 144 dentulous subjects. Each group was divided into subgroups based on gender into male and female, each comprising 72 samples. Each subgroup was further classified based on their facial form into four facial forms (Square, Square tapered, Tapered and Ovoid- 18 samples each) based on standardized photographic analysis. Each facial form had three arch forms (Square, Tapered and Ovoid- 6 samples each). Dentulous arch form was classified based on the position of maxillary incisors and canines.

Complete dentures were fabricated for the edentulous patients. A strain gauge based Bite Force Sensor was used to measure the bite force of right and left side one month after denture insertion. Dentulous group's bite force was also measured. The mean values were recorded for statistical analysis. ANOVA, Tukey's post-hoc test and independent samples T test were performed.

Results showed that among all the subgroups Square facial form and Ovoid facial form had the greatest and least mean maximum bite force respectively and were statistically significant. In most of the subdivisions, Square arch form showed greatest mean maximum bite force with statistical significance. A highly significant difference was noticed in most of the bite force values between males and females of both the groups and also between all the edentulous and dentulous subjects.

CONCLUSION:

Within the limitations of the present study, it can be concluded that:

- Gender, facial form and arch form have an influence on the bite force in both the edentulous and dentulous individuals.
- Evaluating facial form and arch form at the examination level of case history recording in a patient could help us gain some knowledge about their bite force.
- Bite force would be of much help in treatment planning, material selection, prosthesis designing and evaluation and also for further studies on the mechanics of mastication.
- Small sample size and institutional population in this study restrict the field of this study. Studies with much larger sample size and population will provide more accurate and definitive results.

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ANNEXURES

TAMIL NADU GOVERNMENT DENTAL COLLEGE & HOSPITAL, CHENNAI – 3.
TELEPHONE : 044-253403343
FAX: 044- 25300681

Ref No: R. C. NO: 0420/DE/2016 date : 16-03-2016

Sub: IEC review of the research proposals,

Title of the work: Evaluation of maximum bite force in patients rehabilitated with complete denture prosthesis-An Invivo study

Principal Investigator: Dr. Srividhya.S
II year , MDS

Department : Department of Prosthodontics
Tamil Nadu Govt. Dental College & Hospital , Chennai-3

Thank you for submitting your research proposal , which was considered at the Institutional Ethics Committee meeting held on the 03.03 2016, at TN Govt. Dental College and the documents related to the study referred above were discussed and the modifications done as suggested and reported to us through your letter dated 11-03-2016 have been reviewed.

The decision of the members of the committee , the secretary and the Chairperson IEC of TN Govt. Dental College is here under:

Approved	Approved and advised to proceed with the study
Approved with suggestions	----------
Revision	----------
Rejected	----------

The principal investigators and their team are advised to adhere to the guide lines given below:

1. You should get detailed informed consent from the patients / participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the Institution or the Government.
3. You should inform the IEC, in case of any change of study procedure, site, and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s) .
6. You should complete the work within specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/ Professor.

MEMBER SECRETARY,
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

CHAIRPERSON
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

INFORMATION SHEET

- We are conducting a study on "**Evaluation of maximum bite force in patients rehabilitated with complete denture prosthesis - An in vivo study** "among patients
- attending TNGDCH and for this study, we are selecting patients.

- The identity of the patients participating in the research will be kept confidential throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

- Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled.

Name of the patient Signature / Thumb impression

Name of the investigator Signature Date

ஆராய்ச்சி பற்றிய தகவல் படிவம்

1. **செயற்கைப் பல் அணிபவர்களின் அதிகபட்ச கடிக்கும் விசை மதிப்பீடு** செய்தல். இந்த ஆராய்ச்சி செய்யும் பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவமனை மற்றும் மருத்துவக் கல்லூரிக்கு வரும் நோயாளிகள் தேர்வு செய்யப்படுகிறார்கள்.

2. இந்த ஆராய்ச்சியின் நோக்கம் நோயாளியின் முக வடிவத்தையும் தாடை எலும்பின் வடிவத்தையும் கொண்டு அதிகபட்ச கடிக்கும் விசையை மதிப்பீடு செய்தல்.

3. நோயாளி பற்றிய குறிப்புகள் பிறர் அறியா வண்ணம் ஆராய்ச்சி முடியும் வரை இரகசியமாக பாதுகாக்கப்படும். அதை வெளியிடும் நேரத்தில் எந்த நோயாளியின் தனி அடையாளங்களும் வெளியிட வாய்ப்பு கிடையாது.

4. இந்த ஆராய்ச்சியில் பங்கு பெறுவது நோயாளியின் தனிப்பட்ட முடிவு மற்றும் நோயாளிகள் இந்த ஆராய்ச்சியில் இருந்து எப்பொழுது வேண்டுமானாலும் விலகிக்கொள்ளலாம். நோயாளியின் இந்த முடிவு அவருக்கோ அல்லது ஆராய்ச்சியாளருக்கோ எந்த வித பாதிப்பும் ஏற்படுத்தாது என்பதைத் தெரியப்படுத்துகிறோம்.

5. இந்த ஆராய்ச்சியின் முடிவுகள் நோயாளிகளுக்கு ஆராய்ச்சி முடியும் தருவாயிலோ அல்லது இடையிலோ தெரிவிக்கப்படும். ஆராய்ச்சியின்பொழுது ஏதும் பின் விளைவுகள் ஏற்பட்டால் அதை சரி செய்ய தகுந்த உதவிகள் அல்லது தேவையான சிகிச்சைகள் உடனடியாக மேற்கொள்ளப்படும்.

நோயாளியின் பெயர் கையொப்பம்/கைரேகை

முதன்மை ஆய்வாளர்

தமிழ்நாடு அரசு பல்மருத்துவக்கல்லூரி

சென்னை 600003.

INFORMED CONSENT FORM

STUDY TITLE:

"**Evaluation of maximum bite force in patients rehabilitated with complete denture prosthesis - An in vivo study".**

Name:

O.P.No:

Address:

S. No:

Age / Sex:

Tel. no:

I, _____ age _____ years exercising my free power of choice, hereby give my consent to be included as a participant in the study "**Evaluation of maximum bite force in patients rehabilitated with complete denture prosthesis - An in vivo study"**

I agree to the following:

- I have been informed to my satisfaction about the purpose of the study and study procedures including investigations to monitor and safeguard my body function.
- I agree to undergo the procedure involved in the study process.
- I have informed the doctor about all medications I have taken in the recent past and those I am currently taking.
- I agree to cooperate fully throughout the study period.
- I hereby give permission to use my medical records for research purpose. I am told that the investigating doctor and institution will keep my identity confidential.

Name of the patient Signature / Thumb impression

Name of the investigator Signature Date

ஆராய்ச்சி ஒப்புதல் படிவம்

“செயற்கைப் பல் அணிபவர்களின் அதிகபட்ச கடிக்கும் விசை மதிப்பீடு செய்தல்.”

இந்த ஆராய்ச்சி செய்யும் பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவமனை மற்றும் மருத்துவக் கல்லூரிக்கு வரும் நோயாளிகள் தேர்வு செய்யப்படுகிறார்கள்.

பெயர்: வயது/பால்:

ஆராய்ச்சி சேர்க்கை எண்: புறநோயாளியின் எண்:

நான் என் சுயநினைவுடன் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் சேர்ந்துகொள்ள ஒப்புதல் அளிக்கிறேன். கீழ் காணப்படும் நிபந்தனைகளுக்கு ஒப்புதல் அளிக்கிறேன். இந்த ஆராய்ச்சியின் நோக்கமும் அதன் சிகிச்சை முறைகளும் எனக்குத் திருப்தி அளிக்கும் வகையில் அறிவுறுத்தப்பட்டது.

இந்த ஆராய்ச்சியின் பொழுது பொதுவாக அனைவருக்கும் செய்வது போலவே செயற்கைப் பற்கள் பொருத்தப்படும்,அதன் பின்னர் கடிக்கும் விசையை மதிப்பிடுவதற்காக ஓர் கருவி கடிப்பதற்குப் பயன்படுத்தப்படும், என் முக வடிவம் அறிவதற்காக ஒரு புகைப்படம் எடுக்கப்படும் என்று மருத்துவரால் எனக்கு விளக்கிக் கூறப்பட்டது.

நான் மருத்துவ சிகிச்சை முறைக்கு முழுமையாக ஒத்துழைத்து ஏதேனும் அசாதாரண நோய் அறிகுறிகள் ஏற்பட்டால் உடனடியாக என் மருத்துவருக்கு தெரிவிக்க ஒப்புக்கொள்கிறேன்.

என் மருத்துவ குறிப்பேடுகளை மருத்துவ ஆராய்ச்சியில் பயன்படுத்த சம்மதிக்கிறேன். இந்த ஆராய்ச்சி மையமும்,ஆராய்ச்சியாளரும் என் அடையாளத்தை ரகசியமாக வைத்திருப்பதாக அறிகிறேன்.

நோயாளியின் பெயர் கையொப்பம் தேதி

ஆராய்ச்சியாளர் பெயர் கையொப்பம் தேதி

DEPARTMENT OF PROSTHODONTICS

Case history for Completely Edentulous Patients

Patients Name:
occupation:
Sex:
Telephone no:
Age Date:
Address

Chief Complaint:
History of Present Complaint:
Periodontal disease / caries/ both & others
Yes/No
CD/PD/FP.D
Period of edentulousness
Etiology of teeth loss
Previous denture experiences
Type of restoration
Duration of Restoration

Medical History:
Relevant medical history about heart diseases
Diabetes
Tuberculosis
Arthritis
Asthma
Epilepsy
Hypertention_
Rheumatic fever or any other disease.

- _ Anemia, Jaundice and Cyanosis
- _ History of allergies/ hyper sensitivities
- _ Chewing habit - Betel nut, Tobacco chewing
- _ Personal habits - Diet, Smoking, Alcoholic

Clinical Examination

General

- _ General health of patient with build
- _ Examination of lymph nodes

Extra oral

Examination: Facial

Examination:

Facial form : Ovoid/Tapering/square/Squarish ovoid

Profile : Straight/Convex/Concave

Facial symmetry : symmetrical / Asymmetrical

Hair Eye

Complexion:

LipExamination:

Cracking, fissuring at commissures _ Yes / No

Short / Long / Medium

TMJ Examination:

Mouth Opening - Normal / Restricted

Deviation of Mandible _ Present / absent

Tenderness / Clicking / Crepitus _ Present / absent

Muscle Co-ordination

Eye Movements Coordinated / Un-coordinated

Intro Oral Examination

Overall view for any abnormal pathoses in

Mucous membrane _____ , cheeks _____ , lips_____ ,

Ridges _____,

Floor of the mouth _____, hard & soft palate & tongue _____ : ____

Color of Mucosa: Pink / Pale Pink / Pigmented

Saliva

Amount& flow :-Normal/Less/

Consistency : - Thin / Thick / Ropy

Arch Size:

Maxillary - Large/Medium/Small

Mandibular - Large / Medium / Small

Arch Form:

Square / Ovoid /

Tapering

Ridge Contour:

Upper U/V - Bulbous / Flat /Knife edge

Lower U/V - Bulbous / Flat / Knife edge

Ridge Relation:

Class I - Normal/Class II - Prognathic / Class III - Retrognathic

Amount of interridge space (Inter arch\distance} - Less /

Adequate

Resorption:

Maxilla _ Slight / Moderate /Severe

Mandible _ Slight / Moderate /Severe

ATWOOD'S CLASSIFICATION

- ORDER I – PRE EXTRACTION
- ORDER II – POST EXTRACTION
- ORDER III – HIGH WELL ROUNDED
- ORDERIV – KNIFE EDGE
- ORDED V- LOW WELL ROUNDED
- ORDER VI - DEPRESSED

Mucosa covering the Ridge:

_ Firmly attached _____ Yes / No

_ Presence of flabby tissue_____ Present/Absent _____ anterior/ Posterior

_ Hyperplastic changes_____ Present/Absent

Soft Palate Contour (Throat Form) __

Class I/class II/Class III

Lateral Throat form (Disto lingual sulcus) __

Class I/class II/Class III

Bony Undercuts:

_ Anterior ____ _ Present/Absent

_ Posterior __ Present/Absent

Tori:

_ Torus palatinus Present/Absent

_ _ Torus Mandibularis __ Present/Absent

Muscle & Frenum:

Attachments _ Normal /.High

Tongue:

_ Size

_ Movement and co-ordination

Floor of Mouth:

High/Low/Normal

Gag reflex:

Active /Hyper active

Provisional Diagnosis:

Radiography Examination:

Panoramic radiographs are preferred

Impacted Teeth _____ _ Present/Absent

Root stumps _____ _ Present / Absent

Foreign objects_____ _ Present /Absent

Radiolucencies _____ _ Present / Absent

any other findings:-

Treatment Plan:

Treatment advised:
Evaluation of Present Prosthesis

Patient evaluation:

Comfort

Chewing Efficiency Aesthetics

Speech

Clinical Examination:

Speech

Aesthetics

Extension

Retention

Occlusion

Vertical dimension _ Adequate / increased / decreased

Artificial teeth _ Porcelain / Resin

Any complaints:

Prognosis:

Treatment Plan :

Treatment advised

BITE FORCE VALUES

DENTULOUS MALE

Dentulous Male	Arch form	Bite Force in KgF	
		(Right)	(Left)
Square	Square	54.633 45.623 49.371 52.244 51.370 35.682	52.972 43.891 49.112 50.980 53.181 36.101
	Tapered	39.922 51.158 40.163 43.726 37.265 46.817	40.154 53.029 42.344 40.710 40.118 45.359
	Ovoid	41.355 45.127 35.404 37.692 38.109 42.626	42.735 44.633 37.129 42.735 44.633 37.129
Square Tapered	Square	53.609 35.722 39.372 43.117 46.219 50.273	54.101 36.548 43.295 28.342 50.674 37.053
	Tapered	40.856 28.664 51.101 35.853 33.162 36.138	41.295 27.342 50.674 37.053 34.450 38.110
	Ovoid	44.395 42.176 36.319 25.923 44.524 33.115	42.629 41.831 38.768 27.224 42.119 34.306

Tapered	Square	49.726	51.017
		37.102	37.925
		50.362	49.720
		39.115	41.416
		42.365	43.429
		48.317	46.113
	Tapered	40.112	41.871
		35.631	37.451
		31.417	32.027
		49.151	46.986
		45.313	46.720
		39.762	41.118
	ovoid	29.870	26.777
		30.690	30.599
		29.529	27.570
		44.325	43.154
		27.317	26.925
		29.925	32.117
Ovoid	Square	28.176	30.926
		43.917	42.103
		37.103	39.725
		42.112	43.109
		40.397	41.760
		38.765	36.115
	Tapered	28.171	26.386
		34.570	31.188
		40.714	41.326
		43.629	40.119
		38.726	37.976
		34.125	35.362
	ovoid	26.542	29.125
		28.377	27.564
		36.122	38.453
		35.753	34.871
		22.984	25.191
		37.196	35.843

DENTULOUS FEMALE:

Dentulous Female	Arch form	Bite force in KgF	
		(Right)	(Left)
Square	Square	44.423 42.983 33.042 33.714 43.186 42.160	43.861 40.122 35.911 30.156 42.115 38.428
	Tapered	40.611 39.855 30.135 38.114 34.012 27.863	41.100 41.977 28.706 37.110 33.705 25.223
	Ovoid	24.117 30.396 27.426 33.924 26.782 27.936	25.020 27.118 25.726 33.182 27.170 26.425
Square Tapered	Square	40.560 27.421 45.342 36.113 40.826 39.723	42.944 26.016 42.176 38.734 37.116 42.105
	Tapered	35.113 31.729 28.966 40.836 28.711 33.256	37.911 32.113 30.012 42.204 27.936 34.429
	Ovoid	34.060 35.115 27.676 30.726 33.119 30.735	32.908 37.502 28.243 31.926 31.526 33.831

Tapered	Square	29.763 28.834 36.512 37.634 38.943 33.161	30.115 29.196 34.363 38.117 36.524 35.026
	Tapered	31.762 31.603 26.419 35.436 33.121 30.726	33.663 30.771 27.775 34.278 35.196 27.133
	ovoid	27.105 25.446 29.032 29.561 33.521 33.625	24.933 22.086 31.045 31.931 32.116 31.726
Ovoid	Square	35.643 33.716 36.165 36.194 29.884 30.174	33.806 30.618 35.817 34.846 31.110 32.865
	Tapered	23.787 21.668 30.626 30.125 28.309 27.616	21.343 22.711 33.315 33.654 30.718 31.628
	ovoid	21.944 33.181 28.390 24.011 27.320 25.080	20.598 31.774 29.345 25.945 26.661 27.812

BITE FORCE VALUES

EDENTULOUS MALE

Edentulous Male	Arch form	Bite Force in KgF	
		(Right)	(Left)
Square	Square	7.881 6.925 7.540 6.733 7.254 5.306	7.496 7.113 7.180 6.407 7.339 5.840
	Tapered	5.919 6.399 5.819 6.005 5.760 7.023	6.206 6.011 6.076 5.817 4.983 7.763
	ovoid	4.118 4.926 4.887 5.145 5.027 4.939	3.949 4.009 4.186 4.923 5.876 4.178
Square Tapered	Square	5.650 6.105 4.926 5.048 6.414 6.937	6.965 6.971 4.676 4.976 6.935 7.011
	Tapered	5.996 5.128 4.040 6.723 6.112 4.023	5.608 4.592 5.116 6.010 5.678 4.976
	ovoid	5.989 3.147 2.873 3.026 3.629 2.715	5.117 3.476 3.416 3.897 3.184 3.037
Tapered	square	6.005 5.929 4.937 6.187 5.033 4.217	4.994 5.176 6.739 4.138 6.062 5.361

	Tapered	5.424 5.119 4.721 5.395 4.361 4.008	5.012 5.492 4.325 5.421 4.936 4.859
	Ovoid	4.680 5.307 4.118 5.587 3.762 3.903	5.027 5.215 3.788 5.023 4.115 4.023
Ovoid	Square	3.016 3.743 5.225 5.032 5.825 4.420	3.729 3.028 5.139 5.772 5.139 4.006
	Tapered	4.012 5.512 3.996 5.263 3.736 5.109	4.371 5.338 3.037 5.825 3.050 4.939
	Ovoid	4.322 3.960 3.286 4.357 3.438 3.965	4.021 3.735 3.434 4.301 3.208 3.022

EDENTULOUS FEMALE:

Edentulous Female	Arch form	Bite Force in KgF	
		(Right)	(Left)
Square	Square	4.153 4.727 4.119 5.109 3.663 5.002	4.006 4.640 4.287 4.893 3.388 4.723
	Tapered	4.003 4.705 4.710 4.652 4.043 4.029	4.955 4.325 3.824 4.039 4.265 4.186
	ovoid	2.163 3.087 2.937 3.129 4.310 2.217	2.112 3.156 2.543 2.765 3.723 2.032
Square Tapered	Square	4.188 4.275 3.726 4.025 3.816 3.102	3.967 4.384 3.261 4.359 4.019 3.763
	Tapered	3.974 4.147 4.436 3.797 3.822 3.974	4.119 4.234 4.252 3.846 3.439 3.676
	Ovoid	3.114 3.260 3.812 3.004 3.183 4.006	2.879 3.504 3.263 2.173 2.897 4.152

Tapered	Square	3.617 3.224 4.026 3.182 3.244 3.176	3.009 3.526 3.769 3.423 3.041 3.463
	Tapered	3.187 3.409 3.882 3.823 4.117 3.026	3.043 3.612 4.031 3.811 4.214 2.763
	ovoid	3.223 3.105 2.163 2.895 3.017 3.381	3.017 3.324 4.160 2.745 3.115 3.736
Ovoid	Square	3.175 3.029 2.778 2.935 3.426 3.135	2.976 3.543 2.116 2.725 2.893 3.436
	Tapered	3.510 3.138 2.773 2.905 2.225 2.016	3.079 3.261 2.387 2.538 2.526 1.896
	ovoid	1.910 1.652 2.873 2.749 5.109 4.008	1.643 1.994 2.732 1.997 4.939 4.762